JOURNAL OF ANATOMY AND PHYSIOLOGY

SPOLIA ANATOMICA.

By Dr A. W. MEYER. (*From the Division of Anatomy of the Department of Medicine, Stanford University.*)

CONTENTS.

HUMAN.

	PAGE
1. Dorsal lymph nodes	108
2. Dorsal hemolymph nodes	111
3. Bursæ pharyngea	113
4. A supernumerary para-nasal sinus	118
5. Complete unilateral ossification of the stylo hyoid ligament	120
6. An adult heart with a defective ventricular septum and ventricular wall	123
7. An instance of multiple anomalies	128
8. Observations on the presence of duodenal sphincters	129
9. An unrecognised agent in the formation of duodeno-jejunal fossæ	131
10. Accessory anterior serrati	132
11. Bilateral absence of the frontal sinus	132
12. The absence of the long head of the biceps and its effect upon the intertubercular sulcus	133
13. The relation of exostoses to chronic inflammatory processes	136
14. The effect of ankylosis on the internal structure of bones	138
15. A large mastoid foramen (canal)	142
16. An accessory aberrant meningeal artery	143
17. "Kuchenniere,"	143
18. Recessus duodeno-posterior (Broesicke)	147
19. The effect of disuse on articular cartilage	149
20. A skeleton with thirteen well-developed ribs and twenty-five pre-sacral vertebræ	152
21. A case of true congenital diaphragmatic hernia (?) complicated by volvulus of the stomach in a woman fifty-three years old	153

MAMMALIAN.

	PAGE
1. Congenital hyperthyroidism in the sheep	160
2. Triplicate gall bladders in a cat	163
3. The formation of a large subcutaneous bursa in the cervical region in a cat	164
4. Pseudo-hermaphroditism in a goat	165
5. An unusually large, left-sided congenital defect in the diaphragm of a lamb	166
6. Aberrant adrenals in the great omentum of the cat	170
7. Cystic parathymus glands in fœtal sheep	170
8. Cystic thyroid glands in very young sheep fœtuses	171
9. Symmetrical horseshoe kidney in the cat lying dorsal to the vena cava	172

ALTHOUGH most of the specimens here reported and described are perhaps not unique, yet I trust that they are of sufficient interest to anatomists to deserve the attention given them. Some are still in the possession of the writer, others were not preserved after the notes and drawings had been made.

Specimens taken from the human body are grouped alone, and should really have been described and reported by the students themselves, but the exacting nature of the supervision necessary to assure satisfactory reports has deterred me from adopting this course up to the present. The mammalian specimens were obtained in the course of investigations on hemolymph nodes, or, as is the case with a few human specimens, through the courtesy of colleagues or friends. In the discussions following each specimen no attempt is made to give a complete bibliography, and only consulted references that bear directly on the discussion are given.

I. HUMAN.

1. Dorsal Lymph Nodes.

According to Eisler (1) the first dorsal nodes were reported by Lefèvre (2) in the region of the speculum rhomboideum in 1907. Since then, Florence (3) also reported the occurrence of lymph nodes over the region of the trapezius, but only as far caudally as the level of the spine of the first thoracic vertebra, in a case of inflammatory trouble. It is, of course, not at all unlikely that others have also observed nodes on the dorsum caudal to the posterior auricular and occipital groups. Since both these groups of lymph nodes are ill defined, however, and since the number of nodes composing them is subject to considerable variation in number and fluctuation in size, it is not always easy to discriminate clearly between nodes which do and those which do not belong to these groups. This must be evident, it seems to me, to anyone who has tried to palpate the nodes constituting these groups in a large number of living individuals, or who has observed them closely in the dissecting room. In the case reported here there were so many nodes, they were scattered about over such a large area and extended so far caudally, that there can be no question that they belonged to a separate group from the posterior auricular or occipital nodes. The general arrangement and anomalous character of their distribution is well shown in the somewhat diagrammatic sketch in fig. 1.

The body was that of a male Norwegian of about forty-eight years of age, who was evidently in a good state of nutrition at the time of death. There were no evidences of a general hypertrophy of the lymphatic nodes or of present or past lesions of the scalp, but, unfortunately, no data regarding the past history of the case was obtainable.

All of these nodes lay on the deep fascia, and were sufficiently well preserved and well defined to enable students who were doing their first dissection to recognise and isolate them without difficulty. Most of them, too, were sufficiently large to have been easily palpable during life. The

majority were irregularly oval in outline, flattened dorso-ventrally, from 3–7 mm. across and 3–4 mm. thick. Some of them were rather dark in colour; but since the body had lain some time before being embalmed, post-mortem congestion may have been responsible for their dark colour. Unfortunately, their preservation was not such as to make a microscopical examination of any value, but a careful macroscopical examination failed to reveal any very small nodes. Most of them were firmer than usual and had a very definite or even a thick capsule.

Their unusual position naturally suggests the old question of the regeneration and especially the new formation of lymph nodes. It will be recalled that Bartels (4), who reported one case of unusually numerous cubital and brachial nodes and one of an atypically placed cubital node,

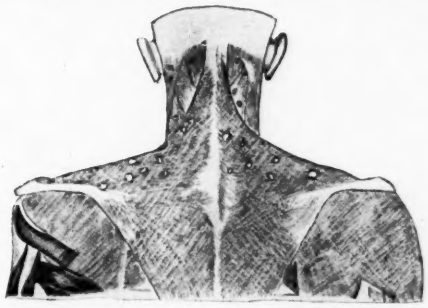


Fig. 1.—Dorsal lymph nodes.

emphasised the fact that such supernumerary and aberrant nodes probably occur only in regions where lymph nodes normally occur or in the path of large lymph vessels. Bartels, who expresses himself with much indecision on the question of regeneration, new formation, etc., in a controversy with Ritter (5), says, however, regarding the nodes reported by him: "Es sind also zwar mehr Lymphknoten also gewöhnlich und an anderen Orten also gewöhnlich vorhanden, aber sie liegen an Stellen, wo stehts wichtige Lymphbahnen verlaufen, also in diesem Sinne doch an typischen Orte." Bartel's conclusion evidently does not hold for the dorsal nodes in this and the succeeding case, for their location is very unusual and there are no especially large lymphatic vessels in the region where they were found. Nor do they lie in regions of rest, but that does not seem to me to be of special significance, although Ritter seems to think it is, in connexion with the formation of nodes under pathological conditions. Although such an origin is quite improbable, it is not denied, to be sure, that the nodes in question

may not have been formed in response to some pathological stimulus, for the mere absence of gross lesions in the cadaver of an individual past middle life does manifestly not exclude such an origin. However, the mere presence of unusually numerous or even aberrant nodes in other than the customary locations cannot be regarded as indicating or as establishing a pathological origin. The conclusion would rather be the opposite. It is true that the main lymph nodes develop in certain definite regions at fairly definite times; nevertheless, the great fluctuations in size, number, and occurrence of lymph nodes in man and animals perhaps need further emphasis in this connexion.

There can be little question that these nodes were mature nodes, and had hence been present a considerable length of time, even if it could be shown that they did not develop from anlagen of prenatal life. It may be recalled that Warthin (6) stated that "in connexion with the question of lymphoid conversion of fat it should be noted here that the work of Bayer on the regeneration of lymph glands in (from) adipose tissue is also confirmed." Unfortunately, the conclusions of Bayer have been abundantly shown to be incorrect, and anyone who doubts the validity of the experimental work of Heuter (7) and Meyer (8) on the regeneration of lymph nodes is respectfully referred to the excellent investigation of Vecchi (9), who states that the observations and conclusions of the latter are confirmed. Nor is there any way of proving that they did or did not arise from a misplaced portion of the dorsal process of the so-called interscapular gland which became superficial in its position. Yet those who justly entertain serious doubts regarding Bonnot's (10) account and conclusions regarding the probable function of the "Fettpolster" of Merkel will not be likely to consider such an origin as a probable one.

(1) Eisler, in a review of (2) in *Jahresbericht u. d. Fortschritte der Anat. u. Entwkgsch.*, 1907, Teil III.

(2) Lefèvre, "Ganglions lymphatiques dorsaux," *Jour. Méd. Bordeaux*, 1907.

(3) Florence, "Au sujet d'un ganglion lymphatique de la région dorsale," *Toulouse Médicale*, 15th Oct. 1909.

(4) Bartels, "Ueber Neubildung von Lymphdrüsen in der Cubitalgegend," *Arch. f. Anat. u. Phys., Anat. Abt.*, 1909.

(5) Ritter, "Zur Neubildung der Lymphdrüsen," *ibid.*

(6) Warthin, "The Changes produced in the Hemolymph Glands of the Sheep and Goat by Splenectomy, Hemolytic Poisons, and Hemorrhage," *Jour. Med. Research*, vol. vii. (N.S.), July 1902.

(7) Heuter, "Uber die Heilungsvorgange nach Resecktion von Lymphdrüsen gewebe," *Verhndl. d. Dtsch. Path. Gesellsch.*, Berl., Mai 1904.

(8) Meyer, "An Experimental Study on the Recurrence of Lymphatic Glands and the Regeneration of Lymphatic Vessels in the Dog," *Bull. Johns Hopkins Hosp.*, June 1906.

(9) Vecchi, *Die anatomischen Grundlagen der Chirurgie der Lymphdrüsen Mitth., aus dem Grenzgbt. der Med. und Chir.*, Bd. xxiii., 1911.
(10) Bonnot, "The Interscapular Gland," *Jour. Anat. and Phys.*, Lond., vol. xliii. 1909.

2. Dorsal Hemolymph Nodes.

The two nodes shown in fig. 2 were located symmetrically on the scapular portions of the latissimi dorsi in the superficial fascia, a few centimeters cranially from the inferior angles of the scapulæ. They lay practically on the vertebral margins of the latter, were irregularly oval in outline, from 6–8 mm. in size, flattened dorso-ventrally, and from 3–4 mm. thick. Because of their unusual position, their dark colour, and particularly because the veins draining them were large and engorged with blood, they looked quite unlike normal lymph nodes, and were unusually

Fig. 2.—Dorsal hemolymph nodes.

conspicuous. Indeed, as far as the prominence of the vein draining them and their colour are concerned, they could easily have been taken for hemolymph nodes. The veins were tortuous, about 2 mm. in diameter, and joined the descending rami of the transverse cervical veins. The arteries, which were very small, had unfortunately been torn before special attention could be directed to them.

The body from which they were taken was that of a male Swede, fifty years old, who had died of delirium tremens. It contained no gross pathological lesions, and the patient had apparently not lost much in weight just before death. Since the body had been unusually well embalmed, twelve hours post mortem, the nodes were found in an excellent state of preservation. Three gallons of a fluid containing 10 per cent. of zinc chloride and 20 per cent. of arsenic by weight, and 2·5 per cent. of formaline and 1·25 per cent. of carbolic acid by volume, had been used in the embalming by the undertaker.

Upon microscopical examination of the sections with low-power magnification, these nodes, which were extremely vascular, seemed to contain both lymph and blood spaces. Most of this vascularity was due to dilated vessels, however, which were very numerous, and in some places composed more than half the area of the parenchyma and trabeculæ. Only slight evidences of rupture of any of these vessels were present. Both nodes have a thick connective-tissue capsule, and contain a great deal of connective tissue throughout some portions of the parenchyma, and

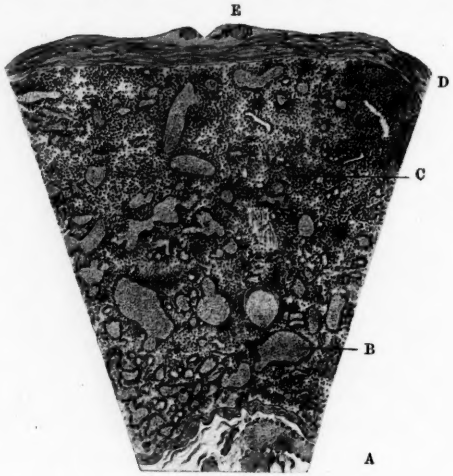


FIG. 3.—Portion of dorsal hemolymph (?) node.

E, blood-vessel in the capsule (D); C, hemorrhagic area; B, lymph sinus containing blood; A, hilum with blood- and lymph-vessels.

especially near the hilum. A definite continuous peripheral sinus was lacking in one of the specimens, but large lymph spaces and lymphatic vessels in section were found, especially near the hilum. Some of the lymph spaces contained blood, and coagulum which suggested lymph but was undoubtedly coagulated serum. There were also many hemorrhagic areas of parenchyma between vessels whose walls seemed to be wholly intact. No follicles were found in the portions examined microscopically, nor could the parenchyma be divided into cortex and medulla. Groups of leucocytes were found in some of the vessels, and also occurred in areas which simulated the blood islands of hemolymph nodes quite closely. Leucocytes were also present in excess in the hemorrhagic areas and in

some of the vessels. No evidences of phagocytosis were noticed, and pigment was not present. One of the specimens contained many acidophile cells, however, with round nuclei but without granules suggesting eosinophiles. Fig. 3 represents a wedge-shaped portion from one of the sections, and gives a fair conception of the appearance of the greater portion of the sections examined.

According to the descriptions, conceptions, and conclusions of Warthin (1) and Meek (2), these specimens are undoubtedly hemolymph nodes. However, that lymph nodes are often congested and hemorrhagic in disease is too well known to need emphasis here, and it was largely because of this fact that Meek (2) came to the conclusion that there are no hemolymph nodes in man. Warthin and others came to exactly the opposite conclusion, however, and it will be recalled that Tixier and Feldzer (3) also noticed hemolymph glands constantly present near the thymus in man. The last investigators found two or three nodes, 2–6 mm. in size, on or in the connective tissue of the thymus, which they regarded as hemolymph nodes. On the other hand, Retterer and Lelievre (4), like Meek, maintained that stasis, etc., could convert a lymph into a hemolymph node. While emphasising the impossibility of distinguishing between hemolymph and lymph nodes by means of gross or microscopical examination of isolated sections, Forgeot (5) claims a rather large experience with vertebrate material, and observations made on the agonal and post-mortem appearance of lymph nodes lead me to believe that the specimens in question are nothing but extremely congested and hemorrhagic lymph nodes.

(1) Warthin, "A Contribution to the Normal Histology and Pathology of the Hemolymph Glands," *Jour. Boston Soc. of Med. Sciences*, vol. v., April 1901.

(2) Meek, "Some Morbid Histological Changes met with in the Lymphatic Glands, especially in connection with the Formation of Hemolymph Glands," *Quarterly Jour. of Med.*, Oxford, vol. iii. No. 12, July 1910.

(3) Tixier et Feldzer, "Note sur l'existence des glandes vasculaires sanguine non décrites juxta-thymiques," *Comptes Rend. Soc. Biol. Paris*, t. 66, p. 21.

(4) Retterer and Lelievre, "Procédé simple pour voir que le ganglion lymphatique possédé les hématies," *Comptes Rend. Soc. Biol. Paris*, t. 68, 1910.

(5) Forgeot, "Sur quelques particularities des ganglion hémolymphatiques des ruminants," *Comptes Rend. Assoc. Anat.*, 11 Réun., Nancy, 1909.

3. Bursæ Pharyngea.

The cysts or bursæ discussed here were all found in the cadavers of white males past fifty. Fig. 4 represents the largest of the three. The tonsils in this subject contained only a small amount of adenoid tissue and a few crypts. They were, in fact, quite sclerotic and atrophic. There was no excess of lymphoid tissue on the tongue, adenoids were not present,

and the nasal conchæ presented nothing noteworthy. The specimen represented in fig. 4 was obtained in median sagittal section with a saw in the course of dissection. It measured 1·6 cm. dorso-ventrally, ·8 cm. from right to left, ·9 cm. cephalo-caudally, and was filled with a finely granular yellowish, friable, fatty mass of soft consistency. Since the volume of this bursa, as determined from a cast, was 0·9 cc., the quantity of contained material was approximately a gram, if allowance is made for reduction in size resulting from the cut of the saw.

FIG. 4.—Bursa pharyngea. ½ natural size.

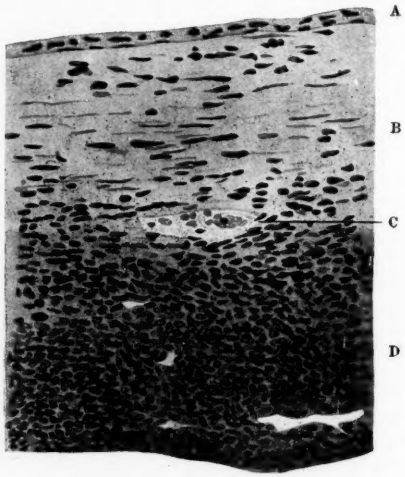


FIG. 5.—Wall of bursa pharyngea.
A, inner syncytial (?) layer; B, fibrous connective tissue; C, blood-vessel; D, adenoid tissue.

It was located directly beneath the ventral or anterior half of the basilar portion of the occipital bone, and lay in almost a horizontal plane crossing the median plane diagonally, so that the greater portion lay on the right side. It extended as far forward or ventrally on the right as the posterior or dorsal fourth of the sphenoidal sinus, but only as far as the dorsal limit of this sinus on the left. If the demarcation seen in the bone superiorly represents the original location of the spheno-occipital synchondrosis, then this bursa is practically bisected by it. The pharyngeal aponeurosis and recti capitis muscles separate it from the adjacent bone and spinal column, and the superior constrictor seems to divide into two leaflets at the dorsal extremity of the bursa, the inferior or caudal leaflet inserting directly into the dorsal extremity of it.

Because of its oblique position comparatively little obstruction was caused to the choana on the left side, but the right was seriously encroached upon. On the latter side the bursa also overlay the pharyngeal recess almost completely, and was practically in contact with the torus tubarius.

The wall of the sac was thin but well defined and smooth internally (see fig. 5). Upon microscopic examination the inner portion of the wall was found to be composed of a syncytium-like layer with elongated oval nuclei. External to this there was a much thicker layer, which formed about half the thickness of the capsule and was composed of connective tissue which contained a few blood-vessels. This connective-tissue layer was gradually replaced by an equally thick cellular layer distinctly adenoid in character. Since the cadaver had been embalmed for some years, all the finer histological characters were, of course, obliterated.

In addition to this specimen two others of like character were found in practically the same location in adults. Both were much smaller, however, and did not extend so far forward. The respective halves of the larger of these had the following measurements in millimeters:

	Right half.	Left half.
Dorso-ventral . . .	9·0 mm.	10·0 mm.
Cephalo-caudal . .	5·5 „	5·5 „
Transverse . . .	6·0 „	7·0 „

This bursa was located directly dorsal to the posterior or dorsal extremity of the sphenoidal sinus. The contents were like those in the one just described, and there was no lymphatic hypertrophy. It was found in a male subject about sixty years old. No histological examination was possible.

The third specimen was only about 3 by 4 mm. in size, but was similar to the rest in other respects.

These bursæ can evidently be regarded as having arisen from (1) the hypophysis pharyngea (Luschka, Erdheim); (2) the recessus pharyngeus medius or pouch of Rathke or Seessel (Meyer); (3) a crypt present in the developing pharyngeal tonsil; or (4) inflammatory adhesions in adenoids.

Since Pende (1) found small cysts containing amorphous, hyaline material in the pharyngeal hypophysis, I see no way in which such an origin for the above cysts can be excluded with certainty. Pende says, however, that he practically always found a connective-tissue capsule around the hypophysis pharyngea or the remnants of it, and that they lie in the spheno-vomerine fossa. The cysts here reported had a connective-tissue capsule on the *inside*, and the smaller two did not extend into the spheno-vomerine fossa. Their position is too far dorsal.

The second origin can, it seems to me, be excluded with considerable certainty, because Meyer (2) found that the bursa pharyngea of adults is firmly attached to the base of the skull and extends through the basilar fibro-cartilage in the region of Seessel's pocket (?), a conception which Huber (3) has shown to be erroneous. Moreover, Tourneux (4), on examining 274 adult crania, found only *one* complete and *four* partial cranio-pharyngeal canals, three of which opened into the naso-pharynx and one into the pituitary fossa.

According to Sokolow (5), who discusses the occurrence of this canal very thoroughly and gives a large bibliography, it was found present in 5 out of 434 adult crania of the Basel collection, or in 1·15 per cent. By averaging the findings of various investigators, Sokolow, however, reports it present in but 3/10 per cent. out of a series of 5281 skulls.

Although, according to writers of experience, the presence of the cranio-pharyngeal canal would seem to coincide approximately in frequency with that of the bursa or cysts under discussion, yet the fact that the latter were wholly free, and that there were no indications of the presence of remnants of cranio-pharyngeal canals, would seem to exclude such an origin. Their position is also too far dorsally or posteriorly. Hence, from the character of these cysts it seems highly probable to me that they arose from the median crypt found in the developing pharyngeal tonsil or from adhesions from inflammatory processes in adenoids. Moreover, French nose and throat specialists have reported cysts in this region which they consider of inflammatory origin. Unfortunately, however, none of these writers considered the possibility of the cysts in question having arisen from the pharyngeal hypophysis of Erdheim.

The fact that such cysts as here reported were never observed in the *faucial* tonsils of cadavers might, however, throw some doubt on their supposed inflammatory origin. Moreover, their deep location and the peculiar relation of the largest to the superior constrictor muscle would seem to require an explanation. However, if the marked changes produced by inflammatory processes in the relations of adjacent structures elsewhere in the body are borne in mind, the peculiar relations of the largest of these cysts to the surrounding structures becomes much less significant, it seems to me. The correctness of this supposition is made all the more probable by reference to fig. 6, which represents conditions as found in a frozen section of a formaline-hardened cadaver of a white male past middle age. In this case the adenoidal mass, which is unusually large and well preserved for this age, contains one cyst approximately $6 \times 4 \times 5$ mm. This cyst, which has a thin connective-tissue wall, is completely surrounded by adenoid tissue. Hence it is very likely that it is of an inflammatory origin, although

its origin from the so-called bursa pharyngea or recess in the developing adenoid cannot be excluded with certainty. It would also be interesting to know whether similar cystic structures occur in races living in the tropics, who are said never to suffer from adenoids.

According to Lelievre and Retterer (6), the development of cysts of the pharyngeal tonsil is preceded by an epithelial hypertrophy of the tonsillar crypts. These crypts, which are lined by a normal mucosa in the beginning, are said to lose their epithelial lining, the wall of the cyst varying in different stages of the evolution of the cysts. Although they arise as a

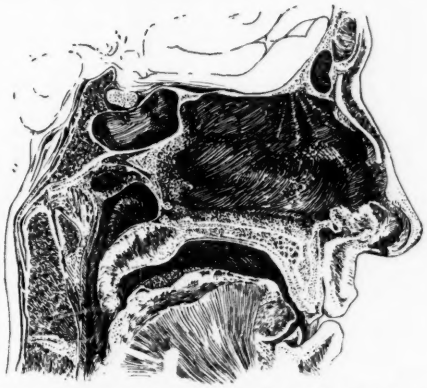


FIG. 6.—Bursa pharyngea surrounded by adenoid tissue. ½ natural size.

result of epithelial hypertrophy, they are finally transformed into retention cysts. These involutionary changes are said to end in the formations of horny (?), mucous masses containing some leucocytes.

(1) FENDE, "Die Hypophysis pharyngea, ihre Struktur und ihre pathologische Bedeutung," *Beitr. z. path. Anat.*, Bd. xlix., Hft. 3, 1910.

(2) MEYER, "Ueber die Bildung des Recessus pharyngeus medius, Bursa pharyngea, im Zusammenhang mit der Chorda bei menschlichen Embryonen," *Anat. Anz.*, Bd. xxxvii., 1910.

(3) HUBER, "On the Relation of the Chorda dorsalis to the Anlage of the Pharyngeal Bursa or Median Pharyngeal Recess," *Anat. Rec.*, vol. vi., 1912.

(4) TOURNEUX, *Base cartilagineuse du crane et organs annexes, etc.*, Thesis, Toulouse, 1910–11.

(5) SOKOLOW, *Der Canalis Cranio-Pharyngeus*, Leipzig, 1904, Thesis, Basel, 1904.

(6) LELIEVRE et RETTERER, "Kystes de l'amygdale pharyngienne hypertrophiée," *C. R. Soc. Biol.*, Paris, 1911, t. 70.

4. A Unique Supernumerary Para-nasal Sinus directly above the Superior Incisors.

Fig. 7 represents the right and larger half of a sinus found on making a median section of the cadaver of a white male approximately sixty years old. The section, which was made with a saw which cut 2 mm. wide, fell a little to the right of the median line and divided the cavity of the sinus into two unequal parts, largely because the sinus was located somewhat asymmetrically. As the drawing shows, it was located directly dorsally and superiorly to the incisor teeth, the roots of which slightly protruded into it along the anterior or ventral wall. On the left side the apex of the root of the central incisor alone reached the cavity; but on the right the roots of

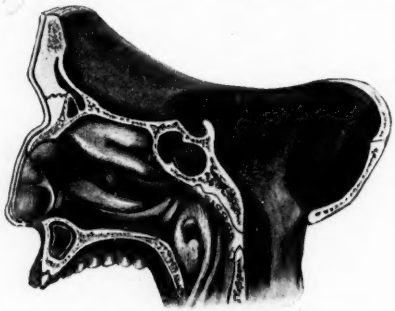


Fig. 7.—Median maxillary sinus.
$\frac{1}{3}$ natural size.

both incisors, and also that of the canine, encroached slightly upon it. Although the line of section lay to the right of the median line, the right half was considerably larger, as the following measurements show:

	Right half.	Left half.
Vertical . . .	1·6 cm.	1·55 cm.
Dorso-ventral . .	1·2 „	1·35 „
Transverse . .	1·4 „	0·80 + 2 mm. for cut.

Hence, if 2 mm. allowance be made for the cut, the total size was approximately $1{\cdot}6 \times 1{\cdot}35 \times 2{\cdot}2$ cm.

Unless the saw destroyed the communication with the nasal cavity on the right side, none was present. On the left, however, a small opening, 2 mm. in diameter, which was encroached upon only very slightly by the saw, is partially preserved in the dorsal portion of the superior wall just lateral to the intermaxillary suture. From this foramen, which opens into the floor of the inferior meatus, a groove extends caudally or inferiorly

along the medial border of the dorsal or posterior wall to a point on the alveolar process just dorsal or posterior to the mid-point of the left central incisor. Unfortunately, the foramen was not noticed early enough to determine the relations of the anterior palatine vessels and nerves to it, and to the above-mentioned groove; but there can be little doubt that they lay in it, and hence very likely passed through the foramen. Moreover, since the size and position of this foramen correspond exactly to the normal foramina occurring in several other specimens, through which the anterior vessels and nerves were known to pass, it does not seem likely that the foramen in question can be regarded as the ostium of the sinus. Besides, the character of the latter and of the bony walls of the sinus was similar to those in the other sinuses, as far as inspection with the unaided eye could determine. The cavity was empty, and the lining membrane especially adherent only to the apices and part of the inner surface of the roots of the protruding teeth. The bony walls were smooth, there was no evidence of disease anywhere in the maxillæ, and all the incisor teeth, save one, were sound. This one, the upper lateral incisor on the right, was decayed several millimeters below the crown; but the root was absolutely sound and the lining membrane over it not thickened or especially adherent.

Because of the presence of all the teeth, and for other reasons, the possibility of this cavity representing a dentigerous cyst or having resulted from an abscess can be excluded, it seems to me. The other possibilities are that it is (1) an accessory maxillary sinus, (2) a bone cyst of other than dentigerous origin, (3) or an independent accessory para-nasal sinus. Since most bone cysts are said to occur in long or pipe bones, to arise in the medulla, to have no capsule, usually to contain hemorrhagic fluid, and to cause expansion of the bone at the place of location, they too can be excluded, for none of these peculiarities were characteristics of the above specimen. There was no new bone formation.

Since this sinus is separated from the maxillary sinuses on either side by an intact bony septum, and since it occupies a median position, it cannot be regarded as a sinus secundarius anterior of Gruber (1), or as a separate chamber of one of the maxillary sinuses as described by Gruber and Zuckerkandl (2). Were the cavity not so large, it might perhaps be regarded as a fused and expanded portion of the anterior palatine canals, but the presence and position of the above-mentioned furrow seems to speak strongly against this supposition. Nor does it seem probable that so large a cavity could have resulted from fusion and expansion of the cupolæ of the sockets of the teeth, even if a satisfactory explanation could be found for the presence and the character of the lining membrane and the relation of the roots of the teeth. Although no mention is made of such super-

numerary para-nasal sinuses by Onodi (3), Le Double (4), Killian (5), or Schaeffer (6), it nevertheless seems very probable to me that it must be regarded as such—a simple *lusus naturæ*.

The only air cell of anthropoids comparable to the above sinus is found, it seems, in *Anthropopithecus niger*. According to Underwood (7), "this accessory air cell, which might be called a suprapalatine sinus, occupies a space intervening between the floor of the nasal passage and the roof of the palate. It is separated from the cavity of the opposite side by a thin bony partition (which is incomplete in front). The cell is about three-

FIG. 8.—Suprapalatine sinus in the chimpanzee. After Underwood. *Jour. of Anat. and Phys.* (Lond.), vol. xliv., 1910, p. 365.

quarters of an inch high in front, just behind the incisor roots, and extends backwards, becoming gradually shallower, until it terminates about an inch behind the level of the last molar" (see fig. 8).

(1) GRUBER, "Sinus secondarius anterior," *Virchow's Archiv*, Bd. cxiii., 1888.
(2) ZUCKERKANDL, *Anatomie d. Mundhöhle*, Wien, 1897.
(3) ONODI, *Die Nebenhöhlen der Nase*, Wien, 1905. "Beiträge zur Kenntniss der Nasennebenhöhlen," *Arch. f. Anat. u. Phys., Anat. Abt.*, 1907.
(4) LE DOUBLE, *Traité des variations des os de la face de l'homme*, Paris, 1906.
(5) KILLIAN, *The Accessory Sinuses of the Nose*, Jena, 1904.
(6) SCHAEFFER, "The Sinus maxillaris and its Relations in the Embryo, Child, and Adult Man," *Am. Jour. Anat.*, vol. x., 1910. "The Lateral Wall of the Cavum nasi in Man, with especial reference to the various Developmental Changes," *Jour. of Morphology*, vol. xxi., No. 4.
(7) UNDERWOOD, "An Inquiry into the Anatomy and Pathology of the Maxillary Sinus," *Jour. Anat. and Phys.*, London, vol. xliv., 1909.

5. COMPLETE UNILATERAL OSSIFICATION OF THE STYLO-HYOID LIGAMENT, WITH THE PRESENCE OF TWO JOINTS.

Although the occurrence of complete ossification of the stylo-hyoid ligament is not rare, the peculiarly jointed condition of this specimen deserves some attention. Gruber (1), in an article, "Ueber enorm lange Processus styloides," published in 1869, stated that the first one to report a

case of complete ossification was Marchetti in an anatomy published in Padua in 1652 (p. 170). Recently Dwight (2) reported a number of specimens, and gave a summary of previously reported cases, with the literature on the subject.

The styloid here reported was 8·5 cm. long, and occurred on the left side in the body of a male past middle life. Since that on the right side was only 2 cm. long, it seems highly probable that there must have been some rotation or lateral displacement even of the hyoid, and perhaps also of the larynx, during life. The dissection had, however, progressed so far when the presence of complete unilateral ossification was noticed, that no observations could be made regarding its effect.

The ossification was regular throughout and the resulting bone quite uniformly cylindrical, although slightly thinner near its articulation with the lesser cornu of the hyoid. Two quite symmetrical annular thickenings are present at the opposite extremities. One is located at the point of articulation with the lesser cornu of the hyoid, and the other approximately six centimeters proximally at what was likely the place of junction of the basi- or tympanohyal with the stylohyal. On examination it was evident that the greater portions of both thickenings were due to fibrous tissue, which formed a well-defined annular band about 3–4 mm. wide and 2 mm. thick at the points of mobility. Mobility at these points was so definite and so evident that it was thought at first that the process had been broken during dissection. Such proved not to be the case, however, and it was found that there were distinct joints at these places and that the mobility was not due to the persistence of unossified portions of the ligament, as is usually the case when ossification has occurred in segments. The apposed ends were quite smooth at these joints; but, since no definite synovial cavity seemed present, they can probably not be considered as true diarthroses. It does not seem unlikely, however, that the partial joint cavities resulted from degeneration in the centre of syndesmoses with fibrous reinforcement externally. It is, to be sure, not an uncommon thing to find jointed styloid processes, and in my experience these have always had purely ligamentous unions, or, when containing small cavities, they have been syndesmoses which permitted the apposed ends of bone to play upon each other more or less. No one except Retterer (3) has reported the presence of true diarthroses, and he did not describe them, although, to be sure, the possibility of their occurrence is not therefore denied.

It is evident that in this particular case the hyoid bone must have been hindered and limited somewhat in its movements during deglutition, as in the case of Richardson (4), and it does not seem improbable that these constantly recurring movements were probably responsible for the presence

of the joints. Under the circumstances, the hyoid bone could manifestly not move as directly upward as it ordinarily does, but it could move to the right and forward to some extent at least. Moreover, it is not at all unlikely that the recurring movements also prevented the process of ossification from completely obliterating the two remaining syndesmoses which made partial mobility possible. This conception is contrary to some extent to that of Retterer, according to whom the stimulating effect of movement may be the main factor in initiating ossification. Nor was the writer so fortunate in his diagnosis of the occupation of the individual as was Saint-Hilaire, as shown by the following quotation taken from Retterer's article: "Averti par l'histoire de l'organisation, dit-il, que des os n'acquièrent jamais un développement extraordinaire, qu'il ne soit occasioné par un violent exercice des muscles qui y ont leur attaché, je me persuadai ques les dimensions de l'hyoide que j'avais sous les yeux pouvaient tenir a la profession de l'individu qui avait fourni cette préparation. Je priai M. Serres de consulter les registres des hôpitaux et de vérifier si, comme je le supposais, l'hyoide qu'il m'avait envoyé ne provenait pas d'un crieur public; je transcris ici sa réponse: 'L'homme dont je vous ai fait remettre l'apophyse styloide était un marchand d'habits et de vieux galons, ayant succombé à une phthisie laryngée, maladie très commune à cette classe de marchands.'

"La chaine styloidienne ne se pouvait reconstituer, dans le sujet qui nous occupé, que du côté droit: il n'en existait de l'autre côté que les éléments comme on les observe habituellement." The writer has not been able to obtain definite information regarding the stylo-hyoid apparatus in the giraffe or in tailed amphibians whose quiet habits have been subject to repeated comments. Hence he respectfully commends the question raised by Saint-Hilaire, with the opinions of the distinguished Frenchman, to the attention of naturalists. It is interesting to note that Saint-Hilaire's conception was adopted by Retterer and an attempt made by him to give it a comparative anatomical basis, in spite of the fact that it is stated that the stylo-hyoid apparatus of mammals and the inferior vertebrates is usually completely ossified.

(1) Gruber, "Ueber enorm lange Processus styloides der Schläfenbeine," *Virchow's Archiv*, l., 1869.

(2) Dwight, "Stylo-hyoid Ossification," *Annals of Surgery*, vol. xlvi., 1907.

(3) Retterer, "Signification des anomalies de l'appareil hyoidien de l'homme," *Jour. de l'Anat. et de la Phys.*, xlvii., 1911.

(4) Richardson, "Elongated Styloid Process," *Trans. Am. Laryngol. Ass.*, N.Y., 1909.

(5) Turner, W., "Hyoid Apparatus and Epi-hyal Bone," *Jour. Anat. and Phys.*, xxxvi., 1902.

6. An Adult Heart with a Defective Muscular Ventricular Septum and Ventricular Walls.

The specimens of trilocular or bilocular hearts which have been reported from time to time have generally been obtained from fœtuses, from the newborn, from infants, or from young children who succumbed early in life as a result of the malformation. The specimen under discussion does not belong to this category, however, for it was found in the body of an individual past sixty-five who had died of a double lobar pneumonia and suffered from a number of pathological conditions in addition to double femoral herniæ. There was intense and almost universal arterio-sclerosis, which extended into the smallest branches at the periphery and which was absent only in the aorta. It was found in the common carotids and iliacs, and in all visceral branches except the splenic, although the cerebral circulation could not be examined because the brain had been removed. Both suprarenal bodies were so cystic that nothing was preserved but a remnant of the cortex and of the medulla of the right one. There evidently had been a severe multiple bursitis, as shown especially by the condition of the patellar and ischial bursæ, and a tubercular arthritis in the humero-scapular articulations with bilateral destruction of the long heads of the biceps, of the joint capsules superiorly, and erosion of the articular surfaces. Half a dozen phleboliths from 2–6 mm. in size were also found in the vesico-prostatic plexus.

The heart in its fixed condition is dilated to about one and a half times normal size. The chief increase in size is due, however, to dilatation of the left ventricle, the conus arteriosus, and the pulmonary artery. The right ventricle is but slightly enlarged, and the arch of the aorta is not markedly dilated. There is a deposit of epicardial fat from 2–4 mm. thick over the right ventricular surface, but almost none over the left. In spite of the pronounced general arterio-sclerosis the coronary arteries were only very slightly affected.

My attention was called to an apparent defect in the musculature of what would ordinarily be the ventral or anterior wall of the right ventricle (see fig. 9). This defective area was marked by a translucent spot, roughly circular in outline and 4 mm. across, which was located 6 mm. to the right of the anterior descending branch of the left coronary artery and 3·7 cm. from the apex of the heart. This portion of the wall was so translucent that it seemed to be composed of the serous membranes alone. It was surrounded by the sub-epicardial fat, and became thicker rapidly to the right, but only very gradually so to the left, as the anterior descending branch of the left coronary artery was approached. Then it became

exceedingly thin again in a direction obliquely toward the apex across the artery, and about one centimeter distant from the other thin area. This second thin area was opaque, however, because of the presence of a thin superficial layer of fat.

In order to make a more thorough examination of these areas, most of the apparently normal left ventricular wall was excised. By inspection by transmitted light it was found that the translucent spot was contained in the wall of the left ventricle instead of the right, as its location had suggested. Both inner and outer surfaces were smooth, and the surrounding musculature, which was very thin, was absent over the whole area. Most of this thin membranous wall was removed later, and, although in a

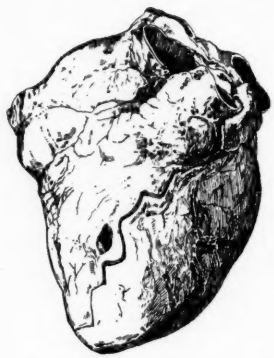


FIG. 9.—Human heart, showing membranous ventricular wall. ⅓ natural size.

very poor state of preservation, was found, upon microscopical examination, to be composed only of connective tissue, fat, and the serous membranes. Both the thin-walled areas lay over a fossa which was formed by a depression in the musculature. This fossa was subdivided by a ridge of muscle which occupied the region beneath the anterior descending branch of the left coronary artery. With the exception of a small circular area about 3 mm. in size, the thin-walled area below and to the left, which was about 6 mm. in size, included a thin layer of cardiac muscle about ½ mm. thick.

The wall of the left ventricle as a whole was thin, the papillary muscles and the numerous well-defined trabeculæ carneæ were decidedly flattened, and the cavity only about 150 per cent. of its normal size. Both aortic and atrio-ventricular orifices were dilated, but the valves were well preserved, though the former were evidently incompetent. Mühsam states, however,

that there is no insufficiency in case of " maladie de Roger," unless there is an isolated hypertrophy.

The most striking thing, however, was the deflection of the incomplete ventricular septum to the right, thus forming an infundibular depression approximately 3·7 by 2·9 cm. in size, containing a large opening (see fig. 10). Since this depression, which was occupied by a post-mortem clot, was flattened ventrally or along the anterior wall, it represented a section of a funnel rather than the whole of it. Upon removing the occluding clot

FIG. 10.—Showing the communication between the ventricles. Part of wall of left ventricle is removed. ½ natural size.

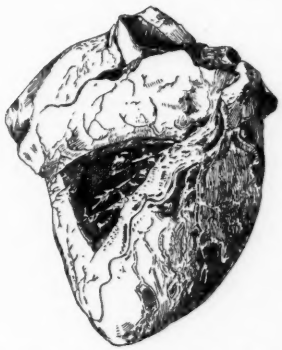


FIG. 11.—The trabeculæ shown in the figure pass anterior, *i.e.* ventral, to the ostium shown in fig. 10. Part of right ventricle is removed. ½ natural size.

it was found that the latter extended into the right ventricle through an opening 1·6 by 1·2 cm. This opening is bridged by a smooth cylindrical cord about 2 mm. thick, partly composed of cardiac muscle, which becomes gradually thicker towards each end where it attaches to the septum. Several smaller strands also extend across the defect, ventral or anterior to the above (see fig. 11). All portions of the opening and the musculature surrounding it were smooth and rounded; there was no cicatricial ring, and no excess of fibrous tissue about the trabeculæ which spanned the oval defect. One centimeter proximally from the opening the ventricular septum was fully 1·2 cm. thick and entirely muscular. The distal or

apical remnant was much smaller, however, and only 5 mm. thick in the thickest portion.

Although great care was used because of the deflection of the septum, it was practically impossible to open the right ventricle sufficiently without cutting and damaging some of the trabeculæ which spanned the interventricular opening. Upon removal of the clot, part of which was still soft, the cavity of the right ventricle was seen to be small, the ventricular wall thin throughout, but especially so as the thin-walled area is approached. The trabeculæ carneæ and papillary muscles were flattened, the right atrioventricular orifice was obliquely opposite the defect in the ventricular septum, and the margins of the tricuspid valves only 1·2 cm. distant from it.

In spite of the dilatation and compression of the walls of the various chambers, the valves retained all their anatomical details. There were no signs of vegetations or ulcerations on any of them, and the chordæ tendineæ, which were extremely delicate, were normal in appearance.

The complete absence of gross pathological lesions anywhere in the musculature of this heart, and the character of the defects, seem to indicate that they must have been present a considerable length of time ante-mortem, although there was no hippocratic clubbing of the fingers and no hypertrophy of the left ventricle. The ductus arteriosus was closed, there were no evidences of syphilis or endocarditis, and there was no pulmonary stenosis, as is said to be usually the case. The entire absence of pulmonary stenosis in this case of uncomplicated interventricular defect is significant, for it confirms Vierordt's conclusion, and it seems to disprove the view that septal defects are the results of stenosis. Moreover, had intra- or extra-uterine inflammatory changes been responsible for this anomaly, one would surely expect to find valvular and endocardial changes. But even if this defect in the septum be regarded as resulting from some degenerative change in the musculature of the heart, the fact nevertheless remains that the lesion was not a recent one, and that the individual must consequently have lived some years with it and with the defective areas in the musculature of both ventricular walls. When the presence of the intense sclerosis, the high blood-pressures frequently associated with it, and the advanced age of the individual at the time of death are taken into consideration, it is difficult, indeed, to realise how life was possible under these conditions. However, even granting that the defects are acquired, since life must have been possible apparently for a period of years in an adult afflicted with such grave lesions, it seems the more likely that we are dealing with a developmental anomaly in spite of the fact that the defect is located somewhat unusually,

for, according to Mall (3), "An open interventricular foramen in the adult always communicates between the aortic vestibule and the space below the medial cusp of the tricuspid valve, as is clear by observing Spalteholz's figure." It is also evident that the defect described had no direct relation to the atrio-ventricular system, as was true in a case referred to by Mall; but I take it that the absence of such an association does not throw doubt upon Mall's conclusions or exclude the possibility of the defect here reported being a developmental one.

That life is possible even for decades with septal defects seems to be clearly indicated by those cases in the literature which were observed clinically for some time. Moreover, the absence of ventricular hypertrophy in this case may in part at least be accounted for by a possible total obliteration of the septal ostium in systole. Hence one might, I think, regard this case as one of an uncomplicated congenital interventricular defect. Bellubekianz (1), after a review of the literature, and while admitting that uncomplicated septal defects are rare, says that Rokitansky was in error when he declared that other anomalies of the vascular system are always associated with congenital septal defects. He says: "Aber est ist unrichtig wenn man früher annahm das einem schweren angeborenen Herzfehler nur ein kurzes Lebensalter gegönnt sei, Wir können aus der Literatur Fälle wo unter bestimmten Umständen auch Menschen mit angeborenen Herzfehler ein höheres Lebens alter erreichen kommen."

Sokolow (2) also recently reported two cases in which the ventricular septum was absent and two in which it was anomalous. He regarded both the defects in the ventricular septum as congenital and not embolic.

Pinner (4) also reported the case of a boy of nine months who had been under observation for several weeks before death, in whose heart the ventricular septum was wholly absent, thus leaving a common cavity. However, in this case other serious anomalies were present. The absence of any protrusion in the region of the weak membranous walls, and the fact that these thin areas did not rupture, seem equally remarkable. The endocardium and visceral pericardium were entirely normal, free from coagulum of any kind, and the musculature around the thin-walled areas was hardly such as to enable it to protect the defective areas during systole by closing in around them and practically obliterating them. Had these thin-walled areas resulted from degeneration, infection, or ulceration, one would rightly expect to find an excess of connective-tissue and some scar-tissue formation, as well as valvular changes. Such was, however, not the case, and I do not know whether local atrophy occurs and whether it could account for these lesions or not.

That very thin regions in the cardiac walls do not necessarily interfere with normal cardiac function is well illustrated by the structure of the ventricle, especially of bovine hearts. In the latter there is an exceedingly thin portion of the cardiac wall, often only 2–3 mm. thick, directly at the apex, although the average thickness of the left ventricular wall is as much as 2·5–3·5 cm. I am not sufficiently informed as to the arrangement of the musculature in the bovine heart, but if this thin apical portion is situated in the centre of a vortex of fibres as represented by Mall (3) in the human heart and by MacCallum (5) in the pig's heart, it is evident that the surrounding musculature would of course close in and so prevent the full systolic pressure from being exerted upon the weak area.

(1) Bellubekianz, *Zwei Fälle von congenitalen Vitien, u.s.w.*, I.D., Berlin, 1910.
(2) Sokolow, "Zur Kausistik der angeborenen Herzanomalien," *St Pétersbourg Méd. Rechr.*, 1910.
(3) Mall, "On the Muscular Architecture of the Ventricles of the Human Heart," *Amer. Jour. Anat.*, vol. xii., 1911.
—— *Ibid.*, vol. xiii. No. 3, 1912.
(4) Pinner, *Ueber einen Fall von Cor biatriatum univentriculare*, I.D., Königsberg, 1911.
(5) MacCallum, J. B., "On the Muscular Architecture and Growth of the Heart," Welch Festschrift, *Johns Hopkins Hospital Reports*, vol. ix., 1900.

7. A Male Cadaver with Multiple Anomalies.

(*a*) The left innominate vein passed around the left side of the heart and opened dorsally and independently into the right atrium directly above, *i.e.* cranially to the inferior cava.
(*b*) The left vertebral artery arose directly from the aortic arch between the common carotid and the subclavian arteries.
(*c*) Absence of the cœliac axis, with independent origin of the vessels normally arising from it.
(*d*) Two distinct renal arteries on both sides.
(*e*) Two accessory renal veins on the left side.
(*f*) The spermatic veins on the left side joined the main renal vein intrarenally.
(*g*) Bilateral double ureters which joined a few centimeters before joining the bladder.

Since the literature on cases of multiple anomalies is such an extensive one, and since the above case throws no new light on these abnormalities, a discussion of the above case or of those in the literature does not seem justified.

8. Some Observations on the Presence of Duodenal Sphincters.

Some years since Ochsner (1) reported the finding of a special broad sphincter in the duodenum, 2–4 cm. below the duodenal papilla, to the action of which he largely attributed so-called idiopathic dilatation of the duodenum. This sphincter, according to Ochsner (2), "consists of a marked thickening of the circular muscle fibres . . . at a point below the entrance of the common duct." The presence of this sphincter was, according to Ochsner, "proved by a large number of dissections," and he adds, "A considerable variation was found in the exact position of these muscle fibres. In some instances they were arranged in a narrow circular band, forming a distinct sphincter; in other instances the thickening was diffused, making a broad circular band; and in a few instances the thickening was in two different bands, with an intervening portion in which the circular muscle fibres were of the same thickness as the remaining portion of the duodenum." Boothby (3) later failed to confirm Ochsner's observations, and strangely enough concluded that the main variation in thickness of the duodenal wall was due to differences in thickness of the mucosa. Shortly after Ochsner published his results with the unconvincing illustrations, the writer began to inspect sections and examine the duodena in dissecting-room subjects in connexion with observations on occasional supernumerary communicating branches between the left and middle colic arteries.

It is, to be sure, an easy matter to find local contractions in the duodenum. These are most common in the pars descendens, vary exceedingly in position, and are often absent altogether. On section the circular coat is found thickened, in the region of the constrictions, much after the fashion of a true sphincter. Such a thickening would, however, be the necessary consequence of a local contraction in any portion of the duodenum, or of the intestinal tract for that matter. Moreover, such contractions and similar thickenings are exceedingly common, especially in the descending, iliac, and pelvic colons, but less so in the ascending and transverse colon and the small intestine. In fact, these contractions seem to be most common in those portions of the intestine which are more intimately united to the abdominal walls. Why this should be so has long been a puzzling question to me, and no satisfactory explanation suggests itself for these contractions, or for the cases of post-mortem intussusception.

Although local contractions which suggest and the resulting local thickenings which simulate sphincters may and do occur frequently in the small intestine in dissecting-room subjects, no one would, to be sure, consider all of them to be the result of the contractions of special sphincters. Besides, it is not improbable that conditions in the duodenum

are such as to make local post-mortem or agonal contractions even more frequent or violent than elsewhere. Then, too, in dissecting-room cadavers the effect of the embalming fluids must not be overlooked. The observations of Beckey (4) and Waterston (5) upon the effect of formaline upon the contraction and shape of the stomach, and of Waterston (6) upon the post-mortem effects of formaline and upon the persistence of irritability in the muscular coats of the intestine, are extremely suggestive and significant in this connexion; but one would scarcely be warranted in concluding that there are special sphincters wherever there is a predisposition to contractility, even if it can be shown, as held by Cunningham (7) for the sphincter antri pylorici of Hofmeister, that such sphincters do exist in a certain percentage of cases. Schwalbe (8), on the other hand, says that such a sphincter cannot be demonstrated. Consequently, whatever the cause of so-called idiopathic dilatation of the duodenum may be, it has not been possible to show that these local contractions of the musculature of the duodenum, which result in local thickenings which simulate sphincters more or less remotely, are after all due to sphincters, and that their occurrence is accompanied by dilatation of the proximal portion of the duodenum. Moreover, if conditions in dissecting-room cadavers can form a fair basis for judgment, the writer seriously doubts whether even considerable obstruction at the duodeno-jejunal flexure is an invariable or necessary cause of dilatation of the duodenum or hypertrophy of its musculature. This leads directly to the next item.

(1) Ochsner, A. J., "Constriction of the Duodenum below the Entrance of the Common Duct, and its Relation to Disease," *Trans. Am. Surg. Ass.*, vol. xxxiii., 1905.

(2) —— "Further Observations of the Anatomy of the Duodenum," *Am. Jour. Med. Sci.*, vol. cxxxii, 1906.

(3) Boothby, "On the so-called Ochsner Muscle of the Duodenum," *Boston Med. and Surg. Jour.*, vol. cliii., 1907.

(4) Beckey, "Contractionsphänomene des Magens und ihre Beziehungen zur Pathologie," *Frankf. Zeitschr. f. Path.*, 1911, Bd. vii. H. 3. Accessible in review only.

(5) Waterston, "The Action of Formalin and the Shape of the Stomach," *Verh. Anat. Ges.*, 24 Vers. Brussel Ergh., *Anat. Anz.*, Bd. xxxvii., 1910.

(6) —— "The Effects of Formalin Hardening and the Persistence of Irritability in the Muscular Coats of the Intestine," *Jour. Anat. Physiol.*, vol. xlv., 1911.

(7) Cunningham, "The Varying Forms of the Stomach in Man and the Anthropoid Ape," *Trans. Roy. Soc. Edin.*, 1906, vol. xli. part 1, No. 2.

(8) Schwalbe, "Beiträge zūr Kenntnis des menschlichen Magen," *Zeitschr. f. Morph. u. Anthrop.*, Sonderheft ii., 1912.

9. A Hitherto Unrecognised Agent in the Formation of Duodeno-jejunal Fossæ, a Recessus duodeni suprema.

Not very uncommonly the left colic artery gives off an ascending branch which runs cranially along the vertebral column a few centimeters lateral to the aorta and parallel to it. If this branch, which is rarely of considerable size, is joined by a left descending branch of the middle colic, a second smaller or accessory anastomotic circle is formed between these two vessels, which usually lies immediately lateral to the duodeno-jejunal flexure, raising a fold of peritoneum as it does so, or it passes across the flexure itself and gives rise to conditions which favour the formation of a retro-peritoneal fossa. In some cases in which the pars inferior of the duodenum was displaced slightly to the left and lay somewhat parallel to the vertebral column, this accessory ascending branch of the left colic lay directly on the left lateral portion of the duodenum and passed across the duodeno-jejunal flexure to join a similar anastomosing accessory descending branch of the middle colic. In some cases the loop formed by these vessels was also joined by a branch which arose directly from the aorta immediately caudal and slightly to the left of the cœliac axis.

These fossæ, which are comparable to the fossa of Landzert in their manner of formation, were usually small, yet in a few cases they were sufficiently large to contain a small portion of the duodeno-jejunal flexure or of the initial portion of the jejunum. Even in the cases in which only a portion of the flexure was included in them, the anastomotic circle was always found to constrict the lumen of the flexure. In two of these cases a loop of the flexure—mainly jejunum—was lodged so firmly in the fossa, and the anastomotic vascular loop constricted it so deeply, that considerable force had to be used to dislodge it, although no adhesions were present. In other instances only the cranial or superior wall of the flexure was constricted and contained in the fossa, but it is evident that all grades between total and partial inclusion of these portions of the intestine are possible.

These para-duodenal fossæ, while similar in origin to the fossa of Landzert, may also give rise to retro-peritoneal herniæ to the left of the duodenum, a fact which was overlooked by Moynihan, who held that those of Landzert were the only ones that could do so.

Such vascular constrictions, even if not so pronounced *intra vitam* as *post mortem*, must offer considerable resistance to peristalsis and the passage of intestinal contents. Yet in no case was any evident hypertrophy of the musculature or dilatation of the duodenum apparent. Nor was such the case in those instances where folds of peritoneum at the flexure or

adherent lymph nodes surrounding the superior mesenteric artery, which had bound down the duodenum to the vertebral column, were found present. In view of these facts it does not seem probable to me that moderate or even considerable obstruction at these points is likely to result in dilatation of the duodenum, recognisable in the dissecting-room cadaver; and that, whatever the cause of dilatation may be, it is unlikely that moderate obstruction is the chief or even an important factor.

10. Two Independent Unilateral Accessory Anterior Serrati in the Male.

According to Le Double (1), a number of investigators have reported muscular slips accessory to the serratus anterior, but none of these correspond exactly to those here recorded. Hence a note may be justified. The small accessory serrati in question were 5·5 cm. long, and 3·2 cm. and 4 cm. wide respectively. Each was composed of two closely associated portions which could be isolated easily. The first and narrowest muscle arose from the second and third ribs and the external intercostal fascia between them, approximately 3 cm. lateral to the angle of the ribs, and was attached dorsal to the serratus anterior along the scapular border, beginning 1·5 cm. caudal to the superior angle of the scapula. The second broader and somewhat thicker muscle had similar attachments directly caudal to the first. It also was composed of two portions. The serratus anterior was well developed and normal in all respects. The nerve supply had been destroyed before attention could be directed to it.

(1) Le Double, *Variations du système musculaire de l'homme*, Paris, 1897.

11. Bilateral Absence of the Frontal Sinus.

Although the entire absence of the frontal sinuses is perhaps not so rare as Schaeffer (1) implies, it is to be doubted whether their absence is as common as Boege (2) reports. The latter, who gives an excellent summary of the literature, found bilateral absence of the frontal sinus in 4 per cent. of the 203 skulls examined.

The skull in which the peculiarity here reported was noticed was taken from the body of a white male 52 years old. The cadaver was entirely normal in all respects, all the other sinuses were present, and diplöetic bone was found throughout the calvarium. None of the para-nasal sinuses were especially large, supernumerary cells or sinuses were not present, and the semilunar hiatus and infundibula were normal on both sides. The

latter were, however, directly continuous with a rudimentary frontal recess which ended in a slightly dilated extremity about 3 mm. superior to the naso-frontal sutures, and could hence hardly be said to extend into the ventral portion of the frontal bone (see figs. 12 and 13). There was no

FIG. 12.—Absence of frontal sinus. Median section. Lateral view. ½ natural size.

FIG. 13.—Same as fig. 12. Median view.

thinning of the latter as in the case reported by Ouston (3), and the region of the sinus is occupied by condensed cancellous bone. For the development of the para-nasal sinus, an explanation of various anomalies found, and further literature on the subject, the reader is referred to Schaeffer (1).

(1) SCHAEFFER, "The Lateral Wall of the Cavum nasi in Man, with especial reference to the various Developmental Changes," *Jour. of Morphology*, vol. xxi., No. 4.

(2) BOEGE, *Zur Anatomie der Stirnhöhlen*, Königsberg, 1902: Thesis, Königsberg, 1902.

(3) OUSTON, "Notes on a Case of Absence of Frontal Sinus," *Northumberland and Durham Med. Jour.*, vol. xviii., 1910.

(4) TURNER, LOGAN, *Accessory Sinuses of Nose*, 1901.

12. BILATERAL ABSENCE OF THE TENDON OF THE LONG HEAD OF THE BICEPS IN ONE SUBJECT, AND FIVE INSTANCES OF SECONDARY ATTACHMENT OF THE TENDON TO THE ARTICULAR CAPSULE AND TUBEROSITIES, WITH SPECIAL REFERENCE TO THE EFFECT OF THESE ANOMALOUS CONDITIONS UPON THE INTERTUBERCULAR SULCUS.

The above instances, which all occurred in adult male subjects, would perhaps scarcely deserve reporting were it not for the fact that they are of interest in connexion with the genesis of the intertubercular sulcus and the effect of pressure and tension upon the form of bones.

In the first case the biceps was fairly well developed in both arms,

and the long head ended in a small, flat, independent, tendinous expansion which was inserted into the shafts of the respective humeri 2·5 cm. proximal to the distal point of insertion of the pectoralis major and immediately medial to it, but independent of it.

In the second case of bilateral, and in one case of unilateral absence, the long heads were secondarily inserted into the articular capsule by means of broad fibrous expansions and into the sulci and the tuberosities as a result of disease.

In the first or normal case there is no question that the intertubercular sulci were shallower, less concave, or rounded transversely, and shorter than is usually the case in subjects of corresponding muscular development and in skeletons of approximately corresponding weight. These differences were especially noticeable in the deepest parts of the sulci, however, where the regularly rounded groove with its smooth floor is usually seen at its best.

Hence it seems to me that it is not at all unlikely that these decided modifications of the intertubercular sulci, especially in their upper portions over the anatomical neck, suggest that pressure exerted by the tendons of the long heads of the biceps is an undeniable factor in their formation. It is true that, as in the cases reported by Joessel (1), there is not a complete absence of the sulcus in these cases, but it does not therefore follow that the pressure exerted by the tendons themselves does not exert a moulding effect on the sulcus. Moreover, Joessel admits that the sulci are shallower in cases of absence of the long head of the biceps, and this in itself is the best possible proof, it seems to me, that tendon pressures do help to determine the relief of bones. Moreover, if, as Joessel seems to think, the intertubercular sulci are produced solely by tension at the points of the muscle insertions along the ridges, it devolves upon him to show why pressure should not also have a corresponding effect. Nor does Hirsch's (2) objection that it would be remarkable if pressure were a factor, because delicate synovial membranes are interposed between tendons and bones, seem a pertinent one. That fact may be remarkable, indeed, but is it not at least as remarkable that these same delicate sheaths are and must be subjected to considerable and constantly repeated pressures as the inevitable result of muscular activity in the normal body? It is also well to remember in this connexion that there are serous membranes—and synovial membranes are, of course, not such,—or true membranes even, quite as delicate as tendon sheaths, which are subjected to considerable continuous pressure without the least damage. Such denials of the effects of pressure on the relief of bones surely cannot throw serious doubt upon the conceptions of Roux and others in this regard. Regarding the normal

specimens under discussion, it is not a question of destruction of adult bone but of the moulding of immature bones during a time of their greatest plasticity—their period of growth. Moreover, transplantation experiments and cases of ankylosis have shown quite conclusively that new surroundings can and do transform bones to a surprising extent.

The five instances of attachment of the tendons of the long heads of the biceps into the articular capsule and tuberosities were not introduced directly into the above discussion, because they are pathological specimens. Yet a careful examination of them shows also that the presence of a remnant of a tendon had a formative effect in the one case in which that tendon was not wholly destroyed as a result of articular disease.

In four of these five cases the portion of the tendons between the tuberosities and the supraglenoid tubercle, *i.e.* practically all the intracapsular portions, was completely destroyed. In each case, probably as the result of inflammatory changes, the tendon obtained a secondary attachment to the articular capsule, to the distal portion of the intertubercular sulcus, and in one case also to the lesser tuberosity. In the fifth case several thin, narrow, fibrous strands of the intracapsular portion of the tendon of the long head were still present, however, although attachments had also been made to the capsule and the shaft near the tuberosities. The remaining strands of the tendon which were still attached to the supraglenoid tubercle, and which had fused with the capsule throughout their extent, nevertheless were able to mould a new sulcus somewhat anterior to the original sulcus over the anatomical neck and part of the head of the humerus, even in a region where erosion of the cartilage and bone had occurred. Such was, however, not the case in the other specimens, in which all the intracapsular portion had been destroyed. In these specimens by far the greatest portion of the intertubercular sulcus had been quite completely obliterated by the disease. Hence it is clear that the pressure exerted by a mere remnant of the tendon was sufficient to form and to mould an entirely new sulcus on the extratubercular portion of the bone—that is, over the neck and a portion of the head of the humerus eroded of its cartilage by disease. The implication is not that pressures which are adequate or effects which are evident in disease are necessarily adequate and evident under normal conditions, but merely that tendon pressures are undoubted factors in the determination of the relief of bones.

(1) Joessel, *Zeitschr. f. Anat.*, His Branne, 1877, Bd. xi.
(2) Hirsch, *Die mechanische Bedeutung der Schienbeinform*, Berlin, 1895.
—— "Uber die Beziehung zwischen dem Neigungswinkel des Schenkehalses und dem querschnitte des Schenkelbeinschaftes," *Anat. Hefte*, Bd. xi., 1899.

13. Unusual Exostoses on Two Humeri and a Femur, with special reference to the Effect of Tension and Pressure upon their Shape and Direction and their Relation to Chronic Inflammatory Processes.

Both of the exostoses on the humeri shown in figs. 14 and 15 were included in the origin of the brachio-radiales muscles. The first and larger was smooth, stout, 6 mm. thick, 1·2 cm. high in the perpendicular, 3·4 cm. long in the oblique, and arose from the lateral epicondylic ridge 6·5 cm.

Fig. 14.—Right humerus, obliquely from the side. ⅓ natural size.

Fig. 15.—Left humerus, from the posterior. ⅓ natural size.

Fig. 16.—Right femur, obliquely from the medial surface. ⅓ natural size.

proximal to the articular surface. It had a rather blunt, rounded extremity, and was directed decidedly distally in the direction of pull of the muscle. The second and lower but more extensive one was considerably smaller, more irregular in shape, and measured 8 × 1·0 × 2·8 cm. in thickness, height, and length respectively. It arose 2·3 cm. proximal to the articular surface, and corresponded in its general direction with the former process. It also was located on the epicondylar ridge and extended proximally over it for about 2·5 cm.

The exostosis on the shaft of the femur shown in fig. 16 was located on the medial surface, 12·3 cm. proximal to the articular surface, arising directly from the shaft where the linea aspera divides into the

epicondylic ridges. It is thin, broad, and flat, perfectly smooth, has a slightly concave ventral surface, and measures 2·3 cm. in length, 3 cm. in width at the base and 2·6 at the extremity, and 3 mm. in thickness. The adductor tubercle is practically absent, but the linea aspera is well marked and the ventral curvature of the shaft of the femur somewhat accentuated.

The tendon of the adductor longus passed immediately ventral or anteriorly to this large, flat process, but the adductor magnus was attached directly dorsal to it. It is more than likely that the combined effects of these two muscles moulded this large exostosis—or perhaps, more properly speaking, this osteophyte—so as gently to curve it ventrally, thus forming an anterior or ventral concavity embracing the adductor longus. This supposition is confirmed by the character of the dorsal surface of the process.

It is not unlikely, it seems to me, that irritation, or perhaps stimulation from muscular activity, was the chief factor in the formation of some of these processes. This supposition is also supported by the fact that all three are located on bony ridges which serve for muscular attachments and the development of which is correlated to a certain extent to muscular development and activity. It should be noted, however, that one of the exostoses on the humeri and that on the femur are found on bones whose distal and proximal extremities respectively showed signs of chronic articular disease. There is, however, little reason to suppose that the disease was the sole, even if the primary, factor in their formation or that they are necessarily manifestations of localised pathological processes alone. Although such an assumption is not necessarily contradicted by the character of the osteophytes themselves, yet it is made unlikely by the occurrence and character of the exostoses in the third or wholly normal specimen. Wurmb (1), who calls attention to the relation between solitary exostoses and traumata, also reports a case in which exostoses arose gradually and wholly spontaneously; and in the cases here reported it is evident that although the exostoses are found near the extremities of the respective bones, they manifestly are not located near the epiphyseal lines. Since there was no indication of rickets in these cases, they would seem to negative Volkmann's conception of the origin of exostoses; and since the respective bones were no shorter than their companions, the hypothesis of Brenner and Meyer also fails of confirmation.

There was no layer of cartilage over any of these exostoses, and none of them contained a medulla. Hence they were probably periosteal and not cartilaginous in origin. Winters (2) states that most solitary exostoses have a periosteal origin, and that all exostoses arise in youth. It is

probable, it seems to me, that a chronic inflammation—chronic arthritis in two cases—played an important rôle by producing a local periostitis where considerable traction was exerted upon the intermuscular septa and produced a congestion and irritation which stimulated bone formation, even if the conception of Weber, as reported by Winters, cannot be considered a causative factor in the formation of exostoses.

(1) Wurmb, *Ein Fall von multiplen Exostoses*, Thesis, Kiel, 1903.
(2) Winters, *Über einen Fall von Exostosis tibiæ*, Thesis, Kiel, 1903.

14. Changes produced in the Structure of Bones by Ankyloses.

I fully realise that the discussion regarding the relation between form and function is not ended, and that this relationship is not always a simple,

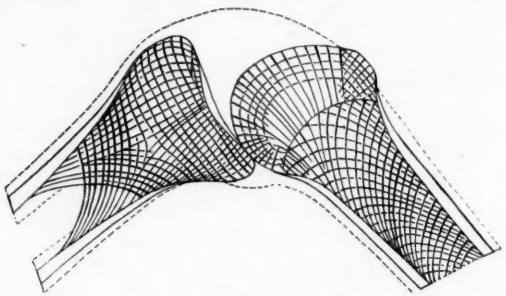


Fig. 17.—Normal architecture at apposed ends of femur and tibia.
After Roux (*Arch. f. Anat. u. Phys.*, 1885, p. 140).

a self-evident, or even a necessary one. It is, however, a decidedly interesting and constantly recurring question.

It will be recalled that Roux (1) reported a case of ankylosis which he thought showed undoubted evidences of functional adaptation, especially of the spongiosa. The specimen was that of the right knee of an adult, which had become ankylosed at an angle of 80°, and in which no line of demarcation between the united ends of the femur and tibia could be found. The compacta forming the dorsal and ventral walls was decidedly thickened, and there had also been a marked readjustment of the spongiosa in both bones.

In order to illustrate these changes, the architecture in the respective ends of the normal femur and tibia are represented diagrammatically in fig. 17, and the composite modified architecture as found by Roux in medial sagittal section in fig. 18. Roux reported, however, that there was some

difference in structure between the medial sagittal section and others taken to the right and to the left of it, in the case reported by him.

According to Roux, this readjustment of the spongiosa had taken place in response to and in harmony with the change in trajectories which resulted from the ankylosis, and Roux illustrated the direction of these new trajectories by means of pressure exerted on a piece of specially prepared gutta-percha. Those interested in the problem will find a discussion in Roux and also in the *Essentials of General Anatomy* by Reinke (2). Triepel (3), who reported the changes produced in the patella in a case of ankylosis, also believed that these were the results of a functional adaptation of its internal architecture to a changed environment.

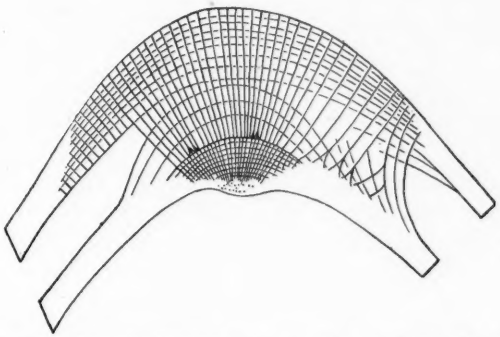


FIG. 18.—Composite diagram of the transformed spongiosa in a case of ankylosis of the knee. After Roux (*Arch. f. Anat. u. Phys.*, 1885, p. 150).

Through the courtesy of a physician, a specimen, likewise of ankylosis of the right knee, from a middle-aged white woman, was obtained in perfectly fresh condition. This ankylosis, which had resulted from a resection of the knee done two years previous to the amputation, had taken place at an angle of 155°. Since the femur had been resected about 1 cm. distal to the adductor tubercle, and the tibia 1 cm. proximal to its tuberosity, about 5 cm. in length of bone had been excised. As the specimen was anatomically entirely normal, it is not necessary to make allowances for or to consider the possible effects of pathological processes. Neither the femur nor the tibia shows a pronounced architecture, nor is this surprising when the sex and the sedentary life of the patient are taken into consideration. A slight displacement of the resected ends had evidently taken place, for, although the apposed ends of the bones were approximately of the same size, the femur projected ventrally and the tibia

dorsally about 1 cm. Only slight absorption of the edges of the projecting ends of the bones had occurred, but the compacta of the region of fusion was evidently much thicker on the dorsal or posterior than on the ventral or anterior surface of the specimen. In the latter region, where a sulcus marked the line of union of the bones, the spongiosa was covered only by a very thin layer of compact bone.

On medial section it was found that the line of union, which was almost completely obliterated, was marked only by a slight condensation in the spongiosa, which extended across the specimen practically at right angles to the long axis of the tibia, but intersected that of the femur at an angle of about 12°. Upon comparing the thickness of the compacta with that found on bones of about equal size, it was apparent that it was thickened somewhat on the dorsal surface of the tibia directly distal to the line of union over the region of greatest concavity, but a corresponding thickening was not present on the ventral or convex surface of the ankylosed bones. Immediately beneath the latter surface some transformation of the spongiosa has apparently also taken place, for the original direction of the trabeculæ was modified. They were also thicker, and the cells of the spongiosa were smaller here instead of larger, as is usually the case in normal specimens. A similar though less marked condensation and thickening of the trabeculæ is also apparent in the dorsal portion of the section, where reinforced trabeculæ leave the compacta and extend gently forward, forming arches with their concavity directed proximally. Shorter trabeculæ also extend inward from the compacta on the dorsal surface. In both bones the arches formed by the trabeculæ on the ventral surface, as represented in fig. 19, have become less characteristic and evident than in the normal specimens, and have united or been transformed to form longer but less curved arches, which span the ventral convex portion of the specimen and lie roughly parallel to the external surface. These arches are not very evident because they are crowded together. They are also thickened, reinforce the union, and are comparable to those in the corresponding portion of the diagram from Roux as represented in fig. 18. Moreover, these modifications of the original structure evidently have occurred in response to functional demands, for as the weight of the body was borne on the ankylosed extremity there was a tendency to increased flexion. Hence the effect of body-weight was to compress or crush the bone dorsally on the concave side and to separate it on the ventral or convex side. These effects were absent, of course, before the ankylosis occurred, for the extremity could then be fully extended and the body-weight in extension be transmitted in a vertical direction. In response to the changed forces resulting from ankylosis, the spongiosa near the

convexity evidently became readjusted and reinforced into a number of parallel arches so as to resist separation by tension, while that on the dorsal or concave surface became condensed and the spongiosa and

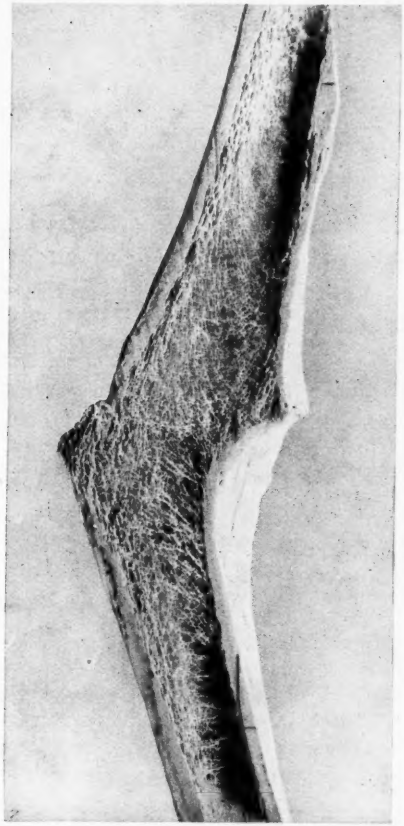


FIG. 19.—Photograph of a median sagittal section of the ankylosed femur and tibia, showing modification of the architecture. ½ natural size.

compacta thickened to resist compression or crushing. It is true that these transformations or adaptations are not very pronounced in this specimen, but it should be borne in mind in this connexion that ankylosis took place at an angle of 155°—a deviation of but 25° from the original normal extended position of the extremity. Moreover, since the patient lived a sedentary life, it could not be expected that a very radical and rapid

readjustment could have taken place under such circumstances. In view of these facts, it seems to me that the above modifications of the original structure are sufficiently evident to justify the interpretation placed upon them.

(1) Roux, "Beschreibung und Erläuterung einer knöchernen Kniegelenksankylose," *Arch. f. Anat. und Phys., Anat. Abt.*, 1885, and *Gesammelte Abhandlungen*, Leipzig, 1895.

(2) Reinke, *Grundzüge der allgemeinen Anatomie*, Wiesbaden, 1901.

(3) Triepel, "Architekturen der Spongiosa bei abnormer Beanspruchung der Knochen," *Anat. Hefte*, Bd. xxv., 1904.

——"Die Knochenfibrillen in transformierter Spongiosa," *Anat. Anz.*, Bd. xxix., Ergänzg. Hft., 1906.

——"Trajektorielle Strukturen," *Anat. Anz.*, Bd. xxiv., 1903.

15. An Abnormally Large Unilateral Foramen mastoideum, Canalis mastoideus, and Sulcus emissarium mastoideum.

Merkel (1), who gives the normal size of the mastoid foramen as somewhat smaller than the "quill of a pigeon's feather," states that the anatomical collection at Göttingen contains a skull with a mastoid foramen large enough easily to accommodate the tip of the little finger. Merkel,

Fig. 20.—Foramen and hiatus mastoideus. ½ natural size.

however, concludes that such a large foramen is the result of yielding of the bones at the base of the skull as a result of rickets, with consequent encroachment on the jugular foramen and a compensatory widening of the mastoid foramen in order to accommodate the increased amount of blood which must pass through it as a result of obstruction of the jugular foramen.

While not desiring to question the correctness of Merkel's conceptions

as to the genesis of the particular large foramen to which he refers, the above specimen illustrates very well that rachitis is not necessarily a factor. There was no evidence of rickets in the skeleton of the white male subject from which the specimen here reported was taken, and the jugular foramen is wholly unobstructed. Notwithstanding this fact, the inner opening of the mastoid canal, which lies in the dorsal border of the transverse sinus approximately 2 cm. lateral to the lateral border of the jugular foramen, has a diameter of 6 mm., and the oval mouth of the sulcus emissarium on the exterior a long diameter of 8 mm. (see fig. 20). This external oval mouth, which lies on a level with the external auditory meatus, forms the entrance to a deep tortuous sulcus which passes into the temporal bone somewhat diagonally upward and forward directly superior to the mastoid cells. There is also a shallower sulcus, which leads into the deeper sulcus above described.

The mastoid emissary vein on the opposite or left side of the skull was, on the contrary almost vestigial, and the foramen and canal so small that they would not admit more than the point of a fine pin. The other emissary foramina were not unusual in any respect.

(1) Merkel, *Topographische Anatomie*, Braunschweig, 1885.

16. A Unilateral Accessory Aberrant Meningeal Artery arising from the Occipital.

The above artery, which arose from the left occipital in the retro-mastoid region, was approximately 3 mm. in diameter and pierced the occipital bone obliquely in the middle of the median nuchal line one centimeter dorsal to the dorsal margin of the foramen magnum. It reached the dura mater at the dorsal, upper and inner margin of the latter, and could be traced upward along the internal occipital protuberance as far as the lambdoid suture. There was only an incomplete sulcus internally to accommodate it, and nothing else noteworthy about the rest of the meningeal arteries.

17. A Transition Form between a Horseshoe and "Kuchenniere."

The following specimen, received through the courtesy of Dr Carl Wilson of Palo Alto, was obtained by him at coroner's autopsy on the body of a white male about 23 years old. After fixation the fused renal mass weighs 300 grams. It is somewhat irregular in outline, there is marked lobulation on the concave ventral surface; but the convex dorsal surface is even, as is customary. The free poles approach each other to within

3 cm., the greater curvature being 40 cm. long and the lesser 12 cm. The total mass measures 14 cm. from right to left, is 5·8 cm. wide, and has a maximum thickness of 4·1 cm. Considering the weight of the normal adult kidney as 120–140 grams, it is evident that the weight of the composite mass is only very slightly, if at all, in excess of the combined weight of two average-sized adult kidneys. And, if we regard the size of

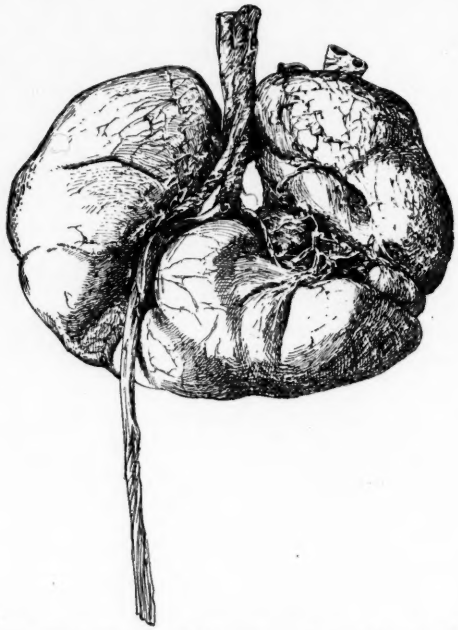


FIG. 21.—Ventral surface of composite renal mass, showing right ureter and left common iliac vein and artery.

the normal kidneys as $12 \times 4–6 \times 3–4$ cm., the same is true regarding the size. Legueu and Papin (1), in an excellent summary of the cases in the literature and from personal observations, state that the combined mass is usually somewhat in excess in weight, and that only rarely does its weight equal that of two normal kidneys, or 300 grams, as given by them.

The sketch in fig. 21 shows that the ventral surface of the specimen is deeply grooved and fissured, divided somewhat distinctly into three portions, and shows a somewhat definite secondary lobulation. The dorsal or posterior surface, on the contrary, is quite even, except for two shallow incomplete sulci located opposite the ventral incisions. Of the three

slightly unequal lobes indicated on the ventral surface, the left or smallest lobe measures 7·7 cm. in length, 5·7 cm. in width, and 3·1 cm. in thickness. The isthmus, or middle lobe, which is the largest of the three, is 8·8 cm. long, 6·3 cm. wide, and 4·2 cm. thick; and the right lobe, which is intermediate in size, measures $9{\cdot}0 \times 5{\cdot}4 \times 4{\cdot}2$ cm. Each of the two larger portions is consequently somewhat smaller than the normal kidney of the adult male. There were only two ureters, one of which was bifurcated near the renal mass. Unfortunately, the greater portion of one of the pelves and the bifurcated ureter were removed at the autopsy, making a more accurate description impossible. From the impressions on the mass, and from the disposition of the arms of the intact pelvis, it is evident, however, that the ureters crossed the ventral surface in the wide interlobular incisions, as is customary in horseshoe kidneys.

Two pelves were fused and joined the left ureter, and all pelves were ventral or ventro-medial in position. Hence it is clear that we are dealing with a bifurcated pelvis, or, judging from the arrangement of the papillæ, perhaps, more properly speaking, with a fused pelvis. The third pelvis, which was intact, still had 13 cm. of the right ureter attached to it. There are no evidences of obstruction.

A group of four radially disposed pyramids in the left extremity of the left lobe ended in one and two papillæ, which emptied into three calices of one arm of the pelvis. One of these calices receives the compound papillæ. The right extremity of the left lobe contains four pyramids, which empty into the other pelvis in common with two other larger pyramids in the left extremity of the median or isthmic lobe. Each of these pyramids has a *distinct* and individual papilla which empties into a separate calyx; but the four other pyramids end in two compound papillæ, each of which receives two pyramids which empty into a single calyx. Hence there are only three calices for the six papillæ and pyramids.

In the right extremity of the median lobe, and in the right lobe, there are nine pyramids of greatly varying size and disposition which open into as many calices, all of which communicate with the right ureter, which is somewhat larger than normal size. This third pelvis is also more nearly of the size and form of a normally-shaped pelvis, although the hilum which lies at the point of the ventral incision is somewhat distorted. The first pelvis arises in a slit in the left lobe, which is approximately parallel to the lateral convex border of that lobe. Hence the total number, or nineteen papillæ, is fully equivalent to or even in excess of the number normally present in two kidneys. Since the pyramids vary considerably in size, however, this numerical excess would be of no significance were it not accompanied by a similar excess in weight and also in size.

All the arteries which had not been cut in the autopsy arose from the *right* common iliac. Two smaller vessels entered the dorsal surface of the left lobe near its outer margin. One entered the median surface of the median lobe; and five, which arose from two trunks, entered at the hilum between the median and right lobes. An accessory artery, with three branches, also entered the dorsal surface of the free pole of the left lobe.

The veins which joined the *left* common iliac were arranged somewhat differently from the arteries. One emerged from the medial extremity of the pelvis of the left lobe; and another, much smaller, from the dorsal surface of the cranial extremity of this lobe at a point opposite the ventral incision between the left and median lobes. Three emerged at the opposite ends of the second pelvis, which was located between the left and median lobes; and six arose in the neighbourhood of the third pelvis, which was located between the right and median lobes.

The form, pelvic position, and gross appearance of the specimen, and the apparent fusion of the two chief hila, strongly suggest the "Kuchenniere" of Haller and Hyrtl; but the presence of a third or minor and independent pelvis in the left or smallest lobe, and the absence of actual fusion of the hila, makes such a designation nevertheless inaccurate. Since the smallest or third hilum lying in the left lobe is independent, and since the pyramids of the combined mass are arranged about three and not about one pelvis, the condition of triplicate kidneys which was suggested by the existence of three fairly distinct groups of vessels, and by the ventral lobulation, seems to be confirmed. Nevertheless, since only two ureters were present, and since the pelvis of the third lobe joined the larger one between the left and median lobes, it seems more likely that this specimen must be regarded as a transition form which has resulted in the usual way by fusion of the caudal poles of two Anlagen, one—the left—of which then became incompletely subdivided into two distinct portions. This conclusion also accords with the rarity of multiple kidneys and with Sappey's conclusion that none of the cases of triplicate and quadruplicate kidneys were probably such. Sappey (2) says, "Schulze, Laurent, Marchetti, au rapport de Haller, auraient observé quatre reins; Molenetti en aurait même vu cinq. Sans repousser ces derniers faits, je ferai remarquer qu'ils n'ont pas toute l'authenticité qu'on pourait désirer; ils ne doivent être admis qu' avec réserve." Nevertheless, Gosset (3) states that a case reported by Josso was probably such. Legueu and Papin also conclude that the term triplicate kidney is wholly unjustifiable, because it is simply a case where one kidney shows a tendency to duplication with more frequent partial duplicity of the ureter of that side. In the case here reported this tendency is splendidly illustrated on the left side, which

had a bifurcated ureter; but the complete fusion of the caudal poles resulted in transforming the isthmus into a definite lobe, largely obscuring it. Were it not for this fact, and for the close approach of the cranial poles, this case is quite similar in form to Case I. as represented and reported by Legueu and Papin, to whose review, covering 300 cases, and to Strube's (4) excellent article, the reader is referred for a fuller discussion of the subject.

(1) Legueu and Papin, *Revue de Gynécologie*, t. xviii., 1912.
(2) Sappey, *Traité d'Anatomie*, 1873.
(3) Gosset, *Traité d'Anatomie humaine*, Poirier et Charpey.
(4) Strube, "Über congenitale Lage- und Bildungsanomalien der Nieren," *V.A.*, Bd. cxxxvii., 1894.

18. Recessus duodeno-posterior (Broesicke).

In their monograph on right-sided herniæ—herniæ mesenterico—parietalis dextra—Eisler and Fischer (1) state that only twenty-four such cases are found in the literature. According to Basset (2), who reported three cases of herniæ duodeno-posterior himself, only three cases belonging in this category had previously been reported. The largest of the hernial sacs in the series reported by Basset measured 18 × 14 cm., and had an opening admitting four fingers. All of these cases, as well as that reported by Merrigan (3), were true herniæ, however, and the occurrence of large peritoneal recesses wholly devoid of contents seems to be rare, for Waldeyer (4), in his well-known investigation on retro-peritoneal herniæ, called attention to the fact that although Treitz reported several cases of beginning retro-peritoneal herniæ, he did not speak of the occurrence of large empty duodeno-jejunal fossæ. Since the case to which attention is directed is not merely a fossa, but an extremely large empty recess, it is of special interest, for it seems to suggest that hernia is not necessarily associated with the formation of large so-called retro-peritoneal sacs.

The body was that of a white male past middle life, in which no other variations or anomalies were present. The opening leading to the recess, which lay directly dorsal to the ascending portion of the duodenum and the duodeno-jejunal flexure, measured 5 cm. cranio-caudally. Because of its position the walls of the portal were in contact, and the latter was undoubtedly guarded to a certain extent by the duodenum. The recess into which this opening led, widened out considerably both cranially and caudally as soon as the duodenum was passed. Its long axis was directed somewhat caudally, and extended to the ascending colon and the body-wall on the right. Cranially it extended to the liver, and caudally to the attachment of the root of the mesentery. It measured approximately 10 × 14 cm.

The mesentery of the transverse colon formed its ventral or anterior wall and the first and second portions of the duodenum lay dorsal to it. Since the right colic flexure lay but a few centimeters cranial to the superior border of the coxal bone, much of the right transverse and a portion of the ascending colon came into relation with the ventral wall of the sac. There was no common mesentery or other anomaly.

Although only a small portion of the colon was somewhat abnormally placed, and although it is not uncommon to find the right flexure as far caudal in cases of enteroptosis, yet the suppositions of Eisler and Fischer that right-sided herniæ are due to the atypical fusion of the ascending mesocolon with the dorsal body-wall would seem to be corroborated, to a certain extent at least. Since the recess was completely empty, however, it would be necessary to suppose that the loops of the small intestine which prevented this fusion in early embryonic life withdrew spontaneously after the recess had formed. Moreover, since it is unlikely that so large a recess could have formed and its walls remained separate so long, one would almost have to assume a later re-entrance of the intestine into the recess and a subsequent withdrawal. Waldeyer considered such an occurrence *possible* but *highly improbable*, for, as he points out, the tendency of peristalsis would be to force more of the intestine into the sac rather than to effect its removal. This reasoning is particularly applicable, it seems to me, to the case in question, for the recess was so large that it could easily have accommodated all of the small intestine. The ventral or anterior wall of the sac would undoubtedly have yielded easily to the pressure of the contained intestine, and formed a large pendulous sac. Moreover, the comparatively small size of the opening and its relation to the duodenum would have predisposed to strangulation, although it is undoubtedly true, as Treitz (5) suggested, that strangulation seldom occurs in cases of duodeno-jejunal herniæ, because they seldom contain more than a single loop of intestine, never any omentum, and especially because the portal of entry, which is non-muscular, is not subject to variation in size.

In spite of the large size of this recess and the accessibility of its portal, it does not seem likely to me that its formation can be ascribed to any of the factors enumerated by Treitz. Nor does it seem probable that it could have been associated by hernia, for the individual apparently had never suffered seriously from complications which one would expect to result from hernia into so large a recess. There were no abdominal scars, and death was due to an unrelated cause.

(1) Eisler and Fischer, *Die Hernia mesenterico-parietalis-dextra*, Leipzig, 1911.
(2) Basset, *Über Hernien der Regio duodeno-jejunalis*, Inaug. Dissert., Berlin, 1908.

(3) Merrigan, "An Unusually Large Peritoneal Fossa," *Anat. Record*, vol. v., 1911.

(4) Waldeyer, *Hernia retroperitonealis nebst Bemerkungen zur Anatomie des Peritoneum*, *A.*, Bd. lx., 1874.

(5) Treitz, "Hernia retroperitonealis," *Ein Beitrag zur Geschichte innerer Hernien*, Prag, 1857.

(6) A number of other articles by Toldt, Waldeyer, Jonnesco, etc., and thesis by Poisson and Gobel were consulted, but for a large bibliography the reader is referred to the monograph of Eisler and Fischer.

19. The Effect of Disuse on Articular Cartilage.

The specimen, of which drawings are shown in figs. 22 and 23, is that of the distal extremity of the right femur, which was affected by a sarcoma. The extremity was obtained through the courtesy of Dr Harry B. Reynolds

Fig. 22.—Distal extremity of the femur, showing the cranially displaced medial condyle. Taken from the ventral surface. ½ natural size.

Fig. 23.—Distal extremity of the femur seen from the medio-dorsal aspect. ½ natural size.

of Palo Alto, by whom the amputation was done. The sarcoma, which had given rise to symptoms for about one year and a half, was limited entirely to the bone. The surrounding tendons and muscles were simply displaced and involved in the dense fibrous connective tissue surrounding

the growth. The knee joint contained a slight excess of synovia, which was clear and opalescent. The capsule was thickened, but the synovial membrane looked quite normal, and the crucial ligaments were preserved. The whole distal extremity of the shaft of the femur, except the articular surfaces of the condyle and a thin layer of the lateral surface of the shaft, had been destroyed, and nothing but a meshwork of thin fragile bone extending around three-fourths of the perimeter supported the body-weight in this region. Although the neoplastic bone was only a few millimeters thick, there was no displacement of the lateral wall of the shaft or of the lateral condyle, the articular cartilage on which was normal in appearance save over a small ventral area. The medial condyle, on the contrary, had rotated dorsally and cranially so as to sustain considerable displacement. The inter-condyloid fossa was practically absent because of the encroachment of the tumor, and the ventro-lateral aspect of the articular surface of the medial condyle was forced out. As a result of bone absorption, the osseous articular surface of the condyle was as thin as paper, and the cartilage practically absent over the neoplastic area, on which most of the patella rested.

The displacement of the medial condyle, due largely to its rotation dorsally, was evidently a very gradual process, for the meshwork of bone which encased the tumor was carried cranially with the rotating condylar surface and presented the appearance of dough or tar into which an object is sinking. Although the osseous articular surface of both condyles was papyraceous, it was practically intact throughout, even in the area in which it lay parallel to and only a few millimeters away from the neoplastic bony network, which had been folded back upon itself.

The bony articular surface of the lateral condyle had been affected, but very slightly, in two places along its medial border by the sarcoma, and the cartilage over it seemed normal. The whole surface of the depressed medial condyle was covered by an uneven layer of smooth fibrous cartilage; and the medial meniscus, which had become adherent, was exceedingly atrophic. In fact, it had become so much thinner that it formed a continuous surface almost on the same level with the rest of the medial articular surface of the tibia. Similar fibrous transformation and atrophy had occurred on the medial condyle, which had been displaced so far cranially that it looked at first as though the condyle had been absorbed. The meniscus over the lateral condyle of the tibia, on the other hand, was well preserved and possessed normal mobility and almost normal thickness.

The changes in the cartilage on the condyles confirm in the main the experimental results obtained by Reyher (1), who found that the articular

cartilages were preserved in their integrity at points of contact in the joints of dogs whose legs had been immobilised for one year. Reyher also found that atrophy and even complete disappearance of the cartilage occurred at points of no contact, just as is the case in the specimen here reported. From his experiments Reyher concluded that the nutrition of cartilage is dependent on friction and pressure, and that atrophy is not due to pressure alone. Menzel (2), whose conclusions were confirmed by Kuhlmann (3) to a certain extent, held a contrary view, however. Menzel, after immobilising the legs of rabbits for a period of approximately two months, found atrophy of the articular cartilage at the points of contact. Kuhlmann thinks that pressure atrophy is here associated with a simple atrophy, and that, in case of defective nutrition of a tissue, atrophy will take place fastest at points of pressure. Kuhlmann's findings corroborate Reyher in that he found the articular area of the bones denuded of cartilage at the points of contact. However, Kuhlmann thinks that his results agree with those of Reyher because some movement was still possible in the joints of the extremities of the dogs used by the latter, in spite of the fact that a plaster bandage was used for purposes of immobilisation.

The absence of articular cartilage and the slight roughening of the osseous articular surface of the patella can be referred to the fact that this area of the patella lay directly in contact with some of the neoplastic bone. Since, however, the articular cartilage, although thin, was preserved at the periphery of the patella, it is more than likely that both the pressure and friction which resulted from the limited movements still possible to the patient were above the threshold stimulus, *i.e.* above the minimum necessary to preserve the cartilage. But this was apparently not the case with the medial condyle and the opposing articular surface of the tibia. That the atrophy of the opposed medial articular cartilages was not the result of excessive pressure in this case is shown conclusively by the fact that the condyle is displaced dorsally and especially cranially. This could of course not be the case if the pressure exerted by the growing neoplasm had caused the displacement, for in that case the medial condyle would have been forced distally instead of proximally.

(1) Reyher, "Über die Veränderungen der Gelenke bei dauernder Ruhe," *Deutsche Zeitschr. f. Chir.*, Leipzig, 1878, Bd. iii.

(2) Menzel, "Über die Erkrankung der Gelenke bei dauernder Ruhe derselben," *Arch. f. klin. Chir.*, 1871, Bd. xii.

(3) Kuhlmann, *Über die Veränderungen in den Gelenken in Folge andauernder Ruhigstellung (im Anschluss an einem Fall von Gelenkneurose)*, Dissert., Kiel, 1898.

20. A Skeleton with Thirteen well-developed Ribs and Twenty-five Pre-sacral Vertebræ.

According to Hyrtl (1), "Eine wirkliche Vermehrung der Rippen durch Vermehrung der Brustwirbel, gehört unter die grössten anatomischen Seltenheiten." Moreover, Hyrtl evidently doubted such an occurrence, for, in discussing the vertebral column, he says, "Eine wirkliche, nicht auf Kosten der Hals—oder Lendenwirbel entstanden Vermehrung der Brustwirbel, gehört unter die grössten anatomischen Seltenheiten." Merkel (2), in discussing variations in the number of vertebræ, says, "Diese Zahlen sind ausserordentlich constant und es gehört eine Vermehrung oder Verminderung der Zahl der Hals—und Brustwirbeln zu den allergrössten Seltenheiten." Merkel, however, considers an increase in the number of lumbar and sacral vertebræ somewhat more common, but rightly emphasises the fact that it is necessary to have the whole vertebral column before one when reporting an increase in number in some region.

Le Double (3) also is of the opinion than an increase in the total number of pre-sacral vertebræ is very exceptional, for he says, "Il n'est pas douteux que les anomalies numériques non compensées des os du rachis thoracique sont infiniment plus exceptionnelles que les anomalies numériques compensées." In the table given by him on page 204, thirty-four cases of the occurrence of thirteen dorsal vertebræ in a series of 1352 spines studied by various anatomists are recorded, but the author himself found only one case in which there was a failure of compensation in a series of 200 vertebral columns examined.

In the skeleton to which attention is directed, the occurrence of a well-developed thirteenth rib was associated with the presence of twenty-five well-developed pre-sacral vertebræ. The case was that of an adult white male showing no other anomalies. The coccyx, which was very rudimentary, was composed of two portions, one of which was completely synostosed to the sacrum. Both portions were composed of a single mass, in which the individual constituents could not be distinguished. The sacrum was perfectly straight to the line of union of the fourth and fifth sacral vertebræ, where a gentle curvature began. This curvature rapidly increased, so that the first portion of the coccyx made an angle of approximately 115° with the rest of the sacrum. The second portion was composed of a small irregular mass which articulated loosely with the first portion.

Eight pairs of ribs articulated directly with the sternum, and the eleventh pair articulated with the seventeenth and eighteenth vertebræ. The nineteenth and twentieth vertebræ carried but one complete costal articular facet. The twentieth pre-sacral vertebra, *i.e.* the one bearing the

last or supernumerary rib, had in general characteristics of a dorsal vertebra, but the inferior articular process is not turned outward, as is usual in the twelfth dorsal, but occupies almost exactly the same plane as those of the two preceding vertebræ (see fig. 24). The spinous process, which is broad and flat, has many of the characteristics of the spinous process of the lumbar vertebræ. The rest of the vertebræ show nothing worthy of special comment.

Since the average length of lumbar ribs is put at 2 cm. by Le Double, and the maximum at 8 cm., and since he states that lumbar ribs when

FIG. 24.—Thirteenth dorsal vertebra. ½ natural size.

present in a pair are usually asymmetrical, one would seem to be justified in concluding that the above specimens are thoracic and not lumbar ribs. Moreover, since the vertebra bearing the thirteenth pair of ribs has the characteristics of a dorsal vertebra, and since eight ribs articulated directly with the sternum, the above conclusion would seem to be substantiated very materially.

(1) HYRTL, *Topographische Anatomie*, 7. Aufl., Wien, 1882.
(2) MERKEL, *Handbuch der topog. Anat.*, Braunschweig, Bd. ii., 1899.
(3) LE DOUBLE, *Traité des variations de la colonne vertébrale de l'homme*, Paris, 1912.

21. A CASE OF HERNIA DIAPHRAGMATICA VERA CONGENITA, ACCOMPANIED BY 180° VOLVULUS OF THE STOMACH.

This rather remarkable instance, probably similar to that of Carruthers (1), of a large, true, congenital diaphragmatic hernia in a woman well advanced in years, would seem to deserve special mention in spite of the fact that it has been justly emphasised of late that diaphragmatic herniæ are not so uncommon as was supposed previous to the use of the X-ray. Moreover, it has also been stated that the presence of a congenital diaphragmatic hernia may give rise to no pronounced symptoms. Vogel (2), for example, stated that the presence of such an extremely large hernia spuria as reported by him may not give rise to any symptoms. To be sure, there may be no symptoms, but their absence does not necessarily imply perfectly normal

functional conditions, for an individual who has never experienced the normal may be quite unconscious of the existence of the abnormal.

In another place (see *infra*, p. 95) the writer reports a case of hernia diaphragmatica spuria congenita in a lamb, which was essentially comparable with the case reported by Vogel in man. In this case the false hernia was undoubtedly responsible for death during labour of a full-term fœtus, which was otherwise of perfectly normal development. It is true that in case of the lamb the stomach was markedly enlarged and distended with viscid fluid, probably largely amniotic fluid, which completely prevented expansion of the left lung and sufficiently impeded that of the right to make post-natal life impossible. That respiratory and not cardiac difficulties must have been responsible for death in this lamb would also seem to be indicated by the fact that except for the slightly increased volume of the right lung with the first inspiration, which increase in volume was probably compensated for by the descent of the diaphragm and the expansion of the chest, there apparently was no interference with cardiac activity. Hence cardiac action was no more interfered with after or during than before birth, for it does not seem probable, even if possible, that the fœtal heart was seriously embarrassed by being forced against a rather large, incompressible and distended stomach by the maternal pressures exerted on the abdomen or chest of the lamb during labour. Moreover, the condition of the lung shows that labour was survived.

Why the case reported by Vogel should have lived to a comparatively advanced age, apparently without experiencing any symptoms, while the lamb referred to died during labour, it is of course impossible to say. However, it is quite certain that the human organism which survived the effects of such a serious defect for decades must have slowly accommodated itself to profoundly altered anatomical conditions. Moreover, that serious functional disturbances were undoubtedly present at birth, and perhaps also during early life, in Vogel's case, would seem to be suggested by the fact that so many of the cases of serious diaphragmatic defect succumb early in life or even soon after birth, and that others which do not survive labour are, no doubt, simply designated as still-born in entire ignorance of the existence of the anomaly and the real cause of death.

The body in which the following developmental anomaly was found was that of a female pauper fifty-three years old. The only thing that attracted attention to the cadaver was its fatness. The panniculus adiposus was from two to five centimeters thick, the breasts were voluminous, but the corpus mammæ atrophic and the papillæ mammæ also atrophic and depressed. The rather rounded thorax was asymmetrical because of a bulging of the third to sixth ribs at the right costo-chondral junctions. The caudal ex-

tremity of the xiphoid process was somewhat elevated. Because of the presence of the unusually thick panniculus adiposus and of a large fibroma uteri which completely filled the pelvis, it is unlikely that marked flattening of the abdomen was present during later life in spite of the displacement of the stomach.

When the abdomen was opened in the course of the dissection, the most noticeable things were the position of the great omentum and the transverse colon. The former, which was wrapped around the colon, extended obliquely across the abdominal cavity from the left hypochondrium to the right lateral abdominal region, where it was adherent. The cæcum, which alone was free and uncovered, overhung the pelvic brim.

The ascending colon was but 7·5 cm. long, and the right flexure situated 2 cm. cranial to the iliac crest. From here it extended diagonally to the seventh costo-chondral junction, where it passed into the thorax beneath a tendinous arch through a large defect in the musculature of the left half of the diaphragm. It reappeared as the descending colon, crossed the hilum of the spleen and reached the left abdominal wall opposite the tenth rib, beyond which its course was normal. Hence it is clear that there really was no transverse colon and no left flexure, but a short direct ascending, a long oblique ascending, and a long oblique and a short straight descending colon instead. Both portions of the loop of the colon contained in the hernial sac and the antral portion of the stomach were enveloped so completely by the omentum that they were invisible till the latter was removed.

The stomach, although actually in the abdominal cavity because of the existence of a hernial sac, was absent in its accustomed location, being represented in the region below the diaphragm—*i.e.* in the normal abdominal cavity—only by a slender tubular pyloric portion 3 cm. long, which lay immediately to the right and parallel to the oblique ascending portion of the transverse colon. The rest of the stomach was wholly cranial to the normal level of the diaphragm, but intraperitoneal. The spleen, although large, was practically normally located lying opposite the ninth and tenth ribs, and extending dorsal to the colon and the antral portion of the stomach and as far medially as the vertebral column. It was visible only at its lower medial border, being supported by an unusually large costocolic ligament (sustentaculum lienis) and veiled by the mesocolon medially. It lay directly caudal to the lateral pillar of the diaphragmatic portal.

The innervation of the diaphragm was normal; and the portal formed by the defect in the diaphragm, which measured 7·7 cm. transversely and 6·0 cm. sagittally, was bridged ventrally by a very definite smooth ten-

dinous arch, from the borders of which the large peritoneal sac was invaginated cranially into the left pleural cavity. Upon removing part of the second to ninth ribs on the left side, the appearance shown in fig. 25 was presented and at once showed that the abnormality was undoubtedly congenital. The left lung, which was adherent nowhere, was composed of two lobes, but both were abnormal in shape and size. The upper lobe, which composed approximately nine-tenths of the total volume of the left lung, was prolonged into a long, thin, narrow tapering process 9 cm. long, which occupied the sulcus between the hernial and pericardial sacs and rested on the left dome of the diaphragm in the eighth intercostal space in the region of the mid-axillary line. The caudal extremity

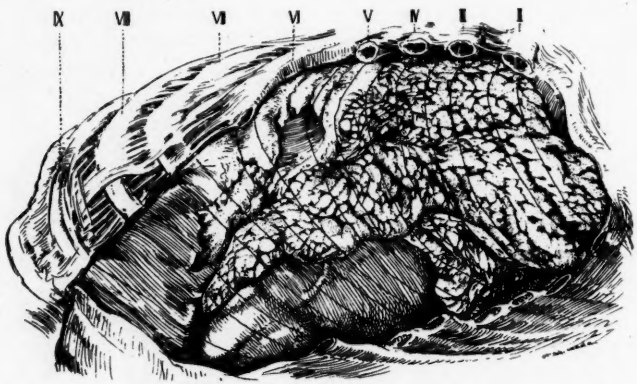


FIG. 25.—Left lateral view, showing the relation of the diaphragm, lung, pericardium, and hernial sac to each other.

of the lower lobe, which was very small and narrow measured 2·5 cm. at the tip and reached only as far as the fifth rib in the scapular line. It extended ventrally only as far as the axillary line and lay on the dome of the hernial sac. The latter, which was entirely filled, was formed by a layer of normal peritoneum and pleura and extended as far cranially as the third rib in the axillary line. It completely filled the portion of the right thoracic cavity, extending from this point to the diaphragm and from the lateral thoracic wall to the hilum of the right lung. It was but slightly constricted at its base, adherent nowhere to the contained or to the surrounding viscera, and composed only of pleura and peritoneum.

The heart, which was practically normal in position, as noted by other observers in cases of diaphragmatic herniæ, and the musculature of the right ventricle of which was but slightly hypertrophied, lay directly ventral

to the hernial sac, the ventral wall of the latter and the pericardium being contiguous. The position and relative size of both are evident from an inspection of fig. 26, in which the lobes of the left lung are reflected cranially.

The highest point reached by the flattened and defective dome of the diaphragmatic musculature on the left is 2·5 cm. caudal to the caudal extremity of the corpus sterni; but the corresponding point on the right lies 4 cm. lateral to the antero-median line at the upper border of the fourth rib, or 4·5 cm. cranial to the above point. Since the highest point of the diaphragmatic attachment in the antero-median line is 2 cm. caudal

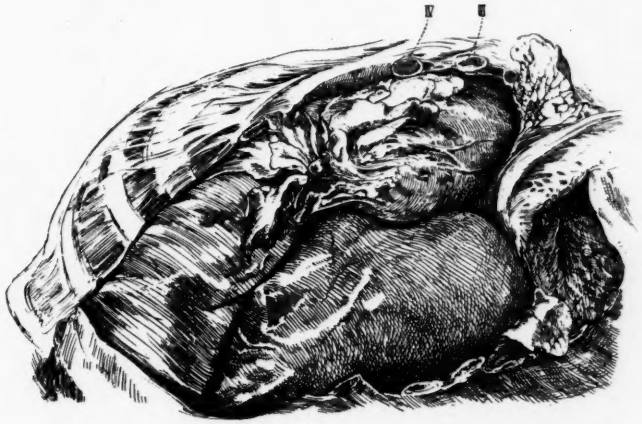


Fig. 26.—Same view as fig. 25, with lung and pericardial fat reflected.

to this point, the difference between the corresponding levels on the two sides is 6·5 cm.

Upon opening the hernial sac by a left lateral incision, the thick, voluminous great omentum was found completely to envelop the loop of the contained colon and formed a large portion of the contents. The stomach was not noticeable, in fact, until both the omentum and colon were reflected caudally and laterally. It was fastened to the aorta and dorsal wall of the thorax by fusion of the peritoneal reflection at the cardia and lesser curvature with the parietal pleura, and extended across the vertebral column to a point dorsal to the hilum of the right lung, the fundic portion of the stomach lying caudal and dorsal to the root of the latter. The stomach was small, cylindrical, almost vertical in position, and practically empty. The fundus and greater curvature, as well as the

tubal pyloric portion, had rotated from left to right. The fundic portion was also folded over ventrally on the rest of the stomach somewhat, because it had exceeded it in rotation, having changed its position 180° from the normal. The rotation of the pyloric portion was only about 45°, and the cardia had not rotated at all. The dorsal wall of the fundus was prolonged into a sacculation which extended caudally toward the lateral wall of the diaphragmatic portal. A fold of the gastro-splenic omentum was attached to it, and it was evident that the sacculation resulted from traction by the spleen, which was held firmly in place by peritoneal reflections and by the arch of the diaphragmatic musculature beneath which it lay.

The œsophagus, which was only 18 cm. long, lay a trifle to the left of its normal position throughout its course, and turned almost directly laterally to the left opposite the sixth costo-vertebral junction. From here it extended slightly caudally to join the stomach opposite the sixth intercostal space dorsally.

From an examination of the anatomical conditions, it seems to me that the volvulus was acquired very gradually as a result of the marked increase in fatness during later years in life, although the great omentum which was wrapped around the loop of the colon and the stomach was so voluminous that it is probable that the deposition of fat in it must have compressed both the colon and stomach. Hence, as a result of prolonged increased pressure within the sac, the fundus would naturally be urged in the direction of least resistance, which was of course toward the right pleural cavity. Since this pressure must have been exerted over a period of years, it is highly probable that the extension of the serous hernial sac beneath the hilum of the right lung and of the pleural cupulæ—especially the right—high up into the neck, as shown in fig. 27, resulted in this way. It is also evident that the heart was subjected not only to periodic but also to an increasing pressure; and the clinical diagnosis of myocarditis at the time of death, and death itself, is easily accounted for. The post-natal production of such a high grade of volvulus would, to be sure, result very seriously under normal conditions, for it is usually rapidly fatal when acquired, even if there is but a partial rotation. However, in this case, the abnormal congenital position of the stomach apparently not only prevented the disastrous effect of volvulus on the vessels, but also obviated torsion at the pylorus and occlusion at the cardia as a result of the rotation. Moreover, it seems probable to me that the volvulus primarily resulted from the increased pressure within the hernial sac as a result of distension of the stomach by amniotic fluid during prenatal life; but, whatever its genesis, it must have had a very gradual evolution, or it would probably have

been incompatible with life at any period. Were it not for the fact that the vagi and the spleen are normally located, one could assume a primary over-rotation of the stomach, but the relation of the fundus to the rest of the stomach would be difficult to explain on this basis.

From an examination of the literature on the subject of congenital diaphragmatic herniæ, it is not at all clear which cases were hernia and which were really primary congenital displacements of viscera which had never reached their normal location. It is evident, to be sure, that if the stomach is found out of its accustomed location it cannot be regarded as being herniated—not even falsely so—unless it can be shown that it once

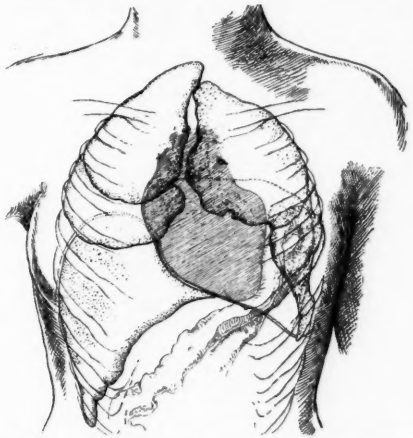


FIG. 27.—Outline sketch showing the relation of the hernial sac to the pericardium and lungs. The sac is shown as a discontinuous red line.

occupied the normal position and was displaced later. In the case under discussion the stomach had apparently never occupied its normal position. In considering the classification of herniæ of the diaphragm, it is hence necessary to distinguish clearly not only between traumatic and non-traumatic herniæ, to subdivide the non-traumatic herniæ reported up to the present as true and false (as has been customary), but also to exclude from the latter primary congenital abnormalities of position, such as the above, which have apparently been included among true herniæ because there was a hernial sac. However, they are plainly not such, and I cannot believe that the case here reported is unique. It is clear, it seems to me, that the so-called sac in this case did, of course, not result from a protrusion through the diaphragm, *i.e.* of a displacement cranially of the stomach, but from the migration caudally of the diaphragm over an

abnormally anchored stomach, the spleen being carried caudally to its normal position by the lateral crescentic portion of the diaphragm.

(1) CARRUTHERS, "Absence of Left Half of the Diaphragm in a Child ten days old," *Lancet*, 1879.

(2) VOGEL, "Diaphragmatic Hernia, with Report of a Case," *Am. Jr. Med. Sci.*, vol. cxlv., 1913.

(3) TUFFIER et JEANNE, "Le volvulus de l'éstomac," *Rev. de Gyn.*, t. xviii., 1912.

II. MAMMALIAN.

1. CONGENITAL HYPERTHYROIDISM IN THE DOMESTIC SHEEP (OVIS ARIES).

Some years since my attention was attracted to the extraordinary size of the thyroid occasionally seen in sheep fœtuses, by the large protrusion on the neck for which it was responsible, and by the extension of the head of the fœtus. This observation is apparently in entire accord with those made on human fœtuses and the human new born, for Ballantyne (1) states in this connexion that "Before birth the life of the fœtus is not threatened; but an abnormal presentation (forehead, face) may be produced, and so delay, and possibly infantile death during labour be brought about."

Schayer (2) states that Virchow estimated the occurrence of congenital struma as 1 to 2 per cent. for the city of Salzburg, and adds that Demme reported that 6¼ per cent. of all cases of hyperthyroidism observed in a children's hospital were congenital in origin. According to the writer's observations, congenital hyperthyroidism in the sheep probably is more common than this, in some localities at least. The mere presence of a prominence on the ventral surface of the neck was, to be sure, not taken as final evidence of thyroid hypertrophy, and hence the possibility that in some of these instances tumors or cysts of other origin were mistaken for goitre, as Ballantyne suggests for the human infant, is thereby excluded. These hypertrophied thyroids of fœtuses in the new born far exceed the size of the normal thyroids in adult sheep, and were not uncommonly accompanied by cyst formation. In a number of cases of hyperthyroidism in adult sheep, examined at the same time, the increase in weight of the gland was approximately tenfold, but in the fœtuses examined it was not uncommonly found to be twentyfold. In view of the extraordinary size which goitre can attain in man, these statements are of course not surprising except in so far as they call attention to, and emphasise the occurrence of, an extreme grade of hyperthyroidism in the prenatal life of the domestic sheep.

A concomitant increase in the size of the thymus or parathymus glands or the presence of anomalies was not observed, but a very striking thing was

the extreme engorgement of the thyroid and jugular veins (see fig. 28), and the fact that the sternohyoid muscles were sometimes imbedded deeply in pressure sulci on the ventral surface of the cranial pole of the lobes of the hypertrophied thyroid glands, as shown in the accompanying illustrations.

FIG. 28.—Congenital hyperthyroidism in the sheep. ⅓ natural size.

This congested condition of the blood-vessels is also mentioned by Schayer, who reported a case in an infant in which it was concluded that the spontaneous and rapid appearance and disappearance of the enlargement was largely a vascular phenomenon. In some cases the muscular impressions were so deep (see fig. 29) and the muscles so tense that the pressure from them would seem to have resulted eventually in division of the lobes

FIG. 29.—Congenital hyperthyroidism in the sheep. The left sterno-hyoid muscle cuts deeply into body of thyroid gland. ⅓ natural size.

unless hypertrophy had ceased. It is also evident that the tension on the muscles would probably have interfered with respiration, as is said to be the case in infants afflicted with congenital struma. No hypertrophy of the infrahyoid muscles, such as was described by Argaud, Billard, and Bataille (3), was noticed, however, although such a hypertrophy might have arisen after birth when these muscles would have been the main supports of the enlarged gland if hypertrophy had continued and not regressed, as is customary.

That cysts of the thyroid may appear extremely early in fœtal life in cases of congenital hyperthyroidism is shown by the fact that a cystic condition accompanied by hypertrophy of the thyroid was found in fœtuses only 9·8 cm. long (V.B.). In the latter case the cysts were 1·5 and 2·2 mm. in size respectively and lay directly beneath the lateral surface of the mid portions of both lobes. Upon microscopical examination the wall of the cyst was found to be composed of flattened epithelium, which enclosed slightly granular hyaline material containing some degenerating erythrocytes and an occasional remnant of parenchyma cells. It was also noticed that some alveoli were dilated and evidently in the early stages of cyst formation. Apart from the contents of these small cysts, nothing which looked like colloid formation was seen in this specimen. In normal specimens of similar age, on the other hand, colloid formation was general; but in the cases of hyperthyroidism parenchymatous hypertrophy was often so intense that the lumina of the alveoli, although very large, were completely obliterated. Only small amounts of colloid were left here and there, and the alveolar walls were very sinuous and folded. Indeed, not infrequently cellular proliferation was so intense that it was difficult to recognise the individual alveoli, simply because the whole alveolus was transformed into a solid epithelial mass. This is in entire accord with the comprehensive observations of Demme, who found 50 per cent of all cases of congenital struma to be a "struma hyperplastica."

In one case, that of a fœtus 30 cm. long, both lobes contained symmetrically placed oval cysts $8 \times 10 \times 12$ mm. which were located in the depths of the cranial pole. In a second case, a superficial spherical cyst approximately 15 mm. in size lay in the ventral surface of the right lobe, and another similarly placed, but only 5 mm. large, on the left lobe. Both of these were also located on the cranial pole of the gland. All these large cysts contained a viscous gelatinous fluid which suggested colloid. If these large cysts possessed a connective-tissue wall it must have been extremely thin, for none could be detected by gross examination alone. Although Bodenstein (4) states that the formation of cartilage is commoner in cystic goitres in infants, it was not found in any of the specimens in the sheep. Nor can it be concluded that the formation of cysts is a very rare occurrence, as Bodenstein states, and as Friedreich, Lebert, Spiegelberg and Hecker held for the human infant, or that they but rarely become of very great size.

Most of these cases of hyperthyroidism were seen in fœtuses 30–39 cm. long (V.B.), but the youngest fœtus measured only 9·8 cm. (V.B.) and was about six weeks old. It is probable, of course, that the condition is recognisable much earlier, but unfortunately no opportunity to continue

these observations has been afforded since. It would be interesting and satisfying in this connexion to know whether these goitres in fœtal sheep disappear spontaneously after birth, as has been stated for infants, and whether any sexual or ancestral influences could be detected.

Since all, save two, of the fœtuses examined were entirely normal in appearance, this simple parenchymatous hypertrophy seems to be without other evident prenatal effects save those enumerated. In a few specimens, however, such an unusually large amount of subcutaneous fat was present that the skin was smooth and tense, the form extremely rounded and so plump that it seems possible that the formation of an unusually thick panniculus adiposus in these instances may be correlated with so-called congenital struma.

(1) Ballantyne, *Antenatal Pathology and Hygiene*, vol. i., Edin., 1902.
(2) Schayer, *Über Struma congenita*, Thesis, Berlin, 1896. (Contains a good bibliography.)
(3) Argaud, Billard, et Bataille, "Sur le rôle de pressure des muscles sterno-thyroidien et sur son hypertrophie au cours du goître," *Journ. de l'Anat.*, No. 5, Sept.-Oct., 1911.
(4) Bodenstein, *Ein Beitrag zur Kenntnis der Struma congenita*, Thesis, Kiel, 1910.

2. Triplicate Gall Bladders in the Cat (Felis domestica).

The multiple gall bladders shown in fig. 30 were found in a male cat about three years old. Upon examination the size and lobulation of the

Fig. 30.—Triplicate gall bladders in the domestic cat. ½ natural size.

liver are practically normal, although all the lobes are somewhat more distinct and several small accessory fissures are present. The left lateral and especially the left median lobes are almost completely separated, and

there is also the attempted formation of an accessory left intermediate lobe. The left median lobe is also completely separated from the right median by the suspensory ligament, which completely separates them. The three gall bladders lie imbedded in the right ventral surface of the cystic lobe; and the apices of the two lateral bladders, which project several millimeters beyond the caudal hepatic border, lie in deep notches in the liver substance. The apex of the third or intermediate gall bladder, which lies in contact with the other two, is capped with a small process of liver substance and has a duct in common with the left bladder. This common duct, which is wide, tortuous, and about 1 cm. long, joins that from the right lateral bladder, thus forming a very straight common cystic duct, which is joined by the various hepatic ducts to form the ductus choledochus. Just proximal to where the hepatic duct from the cranial and caudal divisions of the right lateral and that from the left and right lateral lobes join the common cystic duct, there is a decided ampulla, from the ventral surface of which a blunt conical diverticulum 5 mm. long and 4 mm. wide projects caudally. Because of its shape and position, and in view of the fact that there were three gall bladders in this specimen, this diverticulum can, I take it, be rightly regarded as an attempted formation of a fourth gall bladder.

3. The Formation of a large Subcutaneous Bursa in the Cervical Region in a Cat.

In a male cat about five years old, which had been kept as a household pet, an irregular area of skin on the ventral surface of the neck had been denuded of most of the long hair. This area, which was 2×3 cm. in size, was hyperæmic, but the epidermis was not abraded or infected. Since such an occurrence is not at all unusual, the matter received no further attention until a large subcutaneous bursa was found directly underneath. This bursa, which was largely unilateral, being located mainly to the right of the median line, extended approximately from the body of the mandible to the shoulder, measuring $4{\cdot}2 \times 3{\cdot}5$ cm. Hence it was considerably larger than the area of denudation above it. It contained a small quantity of viscous fluid and had a smooth, somewhat hyperæmic wall. The hyperæmia also extended for $\frac{1}{2}$–1 cm. into the surrounding subcutaneous tissue and into the overlying skin. Upon microscopical examination the smooth bursal wall, which was recognisable microscopically, was found to be composed of connective tissue, the inner layers of which were more closely packed, but there was no indication whatever of an endothelial lining. Hence these observations incidentally confirm the more recent conceptions as to the structure of synovial or bursal membranes.

The genesis of this unusual bursa must, I believe, be attributed to the irritation by scratching. Cats and dogs of this locality are severely infested with fleas [Pulex felis—(cenocephalus canis)], even if kept under the most favourable conditions. The cutaneous irritation produced by these parasites is a particularly intense one on the ventral region of the neck just caudal to the mandible. Hence the animals often scratch these areas vigorously and repeatedly until most or even all of the hair is removed and the skin becomes erythematous and scaly. This repeated superficial irritation must have been accompanied by traction on the subcutaneous areolar tissue, with consequent stretching and loosening of its fibres, but unfortunately no detailed evidence on the genesis of this bursa was obtained. Hence it would be unwise to indulge in speculation regarding the details of the process.

4. A Case of Pseudo-hermaphroditism (?) in a Goat (see fig. 31).

In this animal, which had the external appearance, and to some extent also the habits, of a female, the seat of the vulva was marked by a prominent raphe, which ended ventrally in a symmetrical conical swelling a little over

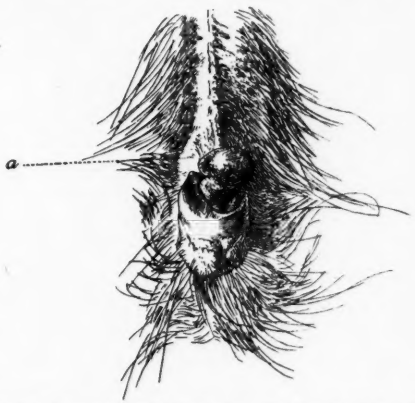


Fig. 31.—Pseudo-hermaphroditism (?) in a goat (see fig. 26). Natural size.
a, Eminence due to dilation of the urethra.

1–1½ cm. long, 1–1¼ cm. wide, and 1 cm. thick. The enlarged extremity which formed the glans penis was attached to a much paler, thinner, and a more cylindrical protruding stalk ½ cm. in diameter, which was surrounded and hooded to a certain extent by a prominent, extremely hyperæmic, hairless cuff of modified skin, which ended ventrally in a still more prominent

portion about 1½ cm. long, from the ventral surface of which numerous long hairs arose in the form of a tuft. The dorsal surface was formed by modified skin, and covered by very short hairs only.

The scrotum, which was normally located, was asymmetrical and so poorly developed as to be scarcely noticeable. Two somewhat undeveloped testicles were present.

Instead of passing cranially toward the umbilicus along the ventral surface of the abdomen, the penis was doubled back upon itself somewhat sinuously, as shown in fig. 32. The most cranial portion of the reduplication was 6·5 cm. ventral to the anus, and the reversal in direction was complete. The urethra, which was plicated longitudinally and of very small calibre, lay ventral to the penis and ended in a small papilla with a prominent ventral lip, which was completely hidden because of its position

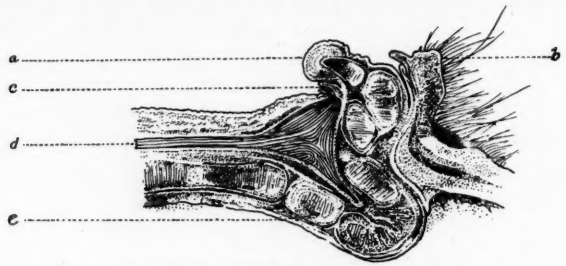


Fig. 32 —Median sagittal section of penis and urethra. Natural size.
a, Glans penis; *b*, prepuce; *c*, urethral orifice; *d*, urethra; *e*, cavernous body of penis.

between the glans and the conical elevation formed by the dilated portion of the urethra. The dorsally directed glans, which resembled that of a monkey quite closely, was exposed freely; and the urethra lay almost exactly in a median plane several millimeters beneath the raphe, and was separated from the glans only by a small fold of the frænum. Although there was no corpus cavernosum urethra, the latter followed the ventral surface of the penis throughout its extent, for it passed up into the acutely flexed portion or elbow of the penis, as shown in fig. 32.

5. Absence of the Left Half of the Diaphragm in a New-born Lamb and its Effect on the Development and Position of the Thoracic Viscera.

Although it is of no special significance in the interpretation of diaphragmatic defects, the following case would seem to deserve discussion since Gössnitz (1), who gave an excellent digest of the literature on the subject,

states that only ninty-nine cases of diaphragmatic herniæ in mammals other than man have been reported, and that only fourteen of these were congenital.

Upon opening the abdomen of this lamb, which had survived birth but a few moments, the most striking thing was the absence of the larger portion of the intestine. As a result of this absence the abdominal cavity seemed empty. Upon examination it was found that the greater portion of the left half of the diaphragm was absent. The left crus was present, however, and the œsophageal opening, although displaced somewhat to the right, was

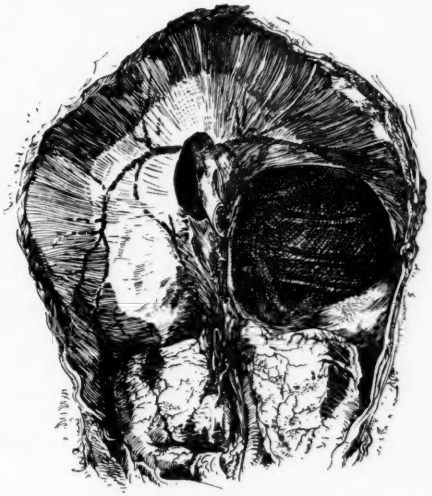


FIG. 33.—Defect in diaphragm of a new-born lamb. ½ natural size.

practically normal. The free border of the central tendon formed an arch which was directly continuous with the left crus and formed a prominent fold, which was attached to the lateral surface of the vertebral column. Ventrally the central tendon was continued in a narrow crescentic slip of muscle which was about 1–1½ cm. wide, and was attached directly lateral to the mid-line. In the margin of the dorsal border of this fold the left branch of the inferior phrenic vein was contained, and formed an arch which ended laterally at the tip of the eleventh rib in the region of the mid-axillary line.

The defect in the diaphragm (see fig. 33), which corresponds to the maximum defect reported by Gössnitz, formed an oval opening 5 × 6 cm. large through which over half of the small intestine, the cæcum, and

a portion of the large intestine, practically all of the distended rumen, the spleen, and part of the pancreas had passed into the left pleural cavity. The stomach, which composed the larger portion of the mass was greatly distended and lay directly upon the left lung with its left extremity. The spleen, which was small, was rotated counter-clockwise, displaced cranially, and occupied a position to the right of the vertebral column between the œsophagus ventrally and the aorta dorsally. The base of the heart was practically undisturbed, but the apex was deflected to the right about 1–1$\frac{1}{3}$ cm. The mediastina were intact, but markedly displaced to the right, caudal to the heart, carrying the œsophagus and aorta with them. In the region of the twelfth vertebra the aorta lay in a median plane directly ventral to the spinal column, and beginning here and going cranially it formed a gentle curve to the right until it had passed completely to the right of the vertebral column in the region of the seventh dorsal vertebra, from where it gradually curved to the left again to reach the base of the heart.

In the region of the eighth to the tenth dorsal vertebra, where the aorta and œsophagus were separated 2·3 cm. dorso-ventrally, the mediastina were deflected markedly to the right, forming a long oval fossa, the caudal portion of which contained the spleen.

The left lung, which was totally collapsed, was only about half normal size and the lobulation was imperfect. The pleura and pericardium were everywhere continuous through the openings in the diaphragm; and the left phrenic nerve, although also deflected to the right in its course caudal to the heart, was apparently unaffected. The right lung, which was somewhat under-developed, had been only partially inflated by attempted respiration.

This defect in the diaphragm is apparently due to failure of the pleuro-peritoneal membrane to form on the left side, thus allowing the stomach, spleen, and other abdominal viscera to pass into the embryonic pleural cavity and preventing the full development of the left lung. Since the liver was normal and fully developed, failure of the left pleuro-peritoneal membrane to form might seem to be called in question, however, for Mall (2) states that "the liver grows into the pleuro-peritoneal membrane while it is being separated from the septum transversum on its ventral side." Perhaps it may be assumed that only a portion of the pleuro-peritoneal membrane formed, and the same may be true of the normally innervated ventral musculature of the diaphragm which failed to extend dorsally. Or it is not unlikely that the liver, which normally invades the pleuro-peritoneal membrane, may be able to continue in its development quite independently of it.

The presence of an apparently normal left phrenic nerve excludes the possibility of a defective innervation of the early musculature, and hence it is evident that the absence of the pleuro-peritoneal membrane probably prevented the musculature which invaded the septum transversum from extending dorsally and laterally, although it may have been prevented from so extending by the presence of the abdominal viscera in the pleuro-peritoneal hiatus. Since the liver was normal, and since none of the displaced viscera—the cardiac end of the stomach, the spleen, intestines, and pancreas—bore any evidence of constriction, it would seem, however, that the diaphragmatic musculature failed to extend dorsally independent of the pleuro-peritoneal membrane although it is present ventrally and has a normal innervation. Hence it seems probable to me that the pleuro-peritoneal membrane acts as an indispensable guide for the ingrowing musculature of the permanent diaphragm. Furthermore, it is possible that the presence of the stomach, or its usually rapid growth cranially, made possible by a slower development of the lung or for other reasons, could prevent the formation of the pleuro-peritoneal membrane and hence make it possible for the musculature to extend into the latter. For, according to Wölfel (3), "Bald shiebt die Leber, die in den ventralen Schenkel des Urnierenbandes hineinwächst, diesen und sich selbst zwischen Lunge und Panzen ein und zwingt den letzteren, sich weiter dorsal aufzurichten, indem sie ihn zugleich mit den Urnierenband den weg in die Pleurahöhlen verlegte." But it is evident that this separation may not be effected if the stomach has encroached too far upon the lung to permit the liver to separate the two viscera by extension into a pleuro-peritoneal membrane which has failed to form, or if degeneration of the pleuro-peritoneal membrane has occurred after separation from it of the liver. Furthermore, since Mall's statement regarding the late closure of the "opening behind the pleural and peritoneal cavities" on the left side in man also holds for sheep, according to Wölfel, the occurrence of this defect on the left may be due to the fact that the stomach, which passed into the gap, prevented the completion or even the formation of the pleuro-peritoneal membrane and the later extension dorsally of the diaphragmatic musculature.

(1) Gössnitz, *Sechs Fälle von linkseitigen Zwerchfelles und Defekt*, Thesis, Jena, 1903. (Gives an extensive bibliography.)

(2) Keibel and Mall, *Human Embryology*, vol. i., Phil., 1910.

(3) Wölfel, *Beiträge zur Entwickelung des Zwerchfelles und Magen bei Wiederkäuern*, Thesis, Giessen, 1907.

6. Aberrant Adrenals in the Great Omentum of the Cat.

In the course of an investigation upon accessory spleens and hemal nodes, small reddish nodules one to three millimeters in size, which, upon microscopical examination, were found to be adrenals, were usually mistaken for accessory spleens. Since not all accessory spleens found were examined microscopically, it is possible that an examination of all specimens would probably have revealed more adrenals. Since both adrenals found were taken from the omentum of the same animal, the

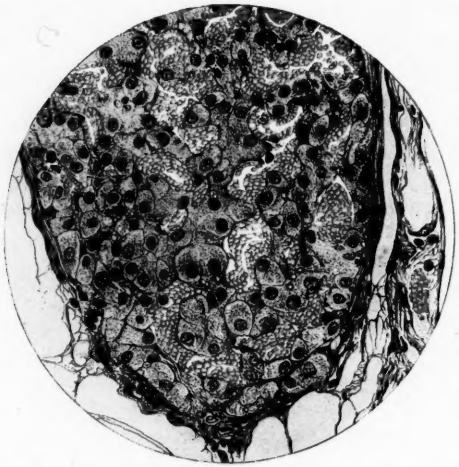


Fig. 34.—Aberrant adrenal from omentum of cat. ×505. Zeiss 3-E.

ratio of their occurrence would stand as one in sixty-nine cats. This included cats of all ages and in somewhat varying conditions of health. In one of these specimens of aberrant adrenals the parenchyma is arranged somewhat characteristically, but in the other this is not the case, as fig. 34 shows. Moreover, some portions of this specimen are extremely vascular and the cells vary considerably in size.

7. Cysts of the Parathymus of the Sheep.

The occurrence of cysts in the parathymus glands of the sheep was observed by Schaper (1), and was also called attention to by Meyer (2). The unusual size and the presence of a group of these cysts, occasionally

seen in fœtal sheep, is quite remarkable. Fig. 35 represents a section of the parathymus from a sheep fœtus 26 centimeters long. In this specimen only the largest of the cysts contained some material of a colloidal nature, but since the occurrence of colloid is not at all rare in developing parathymus glands, it does not seem unlikely that cyst formation is directly attributable to an accumulation of colloid. Although no very large number of parathyroids from adult sheep were examined, yet it seems strange that not a single cystic specimen was found among them, and it is surprising

FIG. 35.—Cystic parathymus from sheep fœtus, 26 cm. Camera lucida. ×97.

that the production of colloid and cyst formation are present during the marked growth of embryonic life.

(1) SCHAPER, "Über die sogenannten Epithelkörper (Glandulæ parathyroideæ) in der seitlichen Nachbarschaft der Schilddrüse und der Umgebung der Arteria carotis der Säuger und des Menschen," *Archiv f. mikr. Anat.*, Bd. xlvi., 1895.

(2) MEYER, "The Occurrence of Intra-thoracic Parathyroid Glands," *Anat. Record*, vol. iii., 1909. *Proc. Ass. of Am. Anat.*, pp. 272–274.

8. CYSTIC THYROIDS IN VERY YOUNG SHEEP FŒTUSES.

The youngest fœtus in which the thyroids were found to be markedly cystic was only 9·7 cm. long. As the rough sketch in fig. 36 shows, these cysts were relatively very large and contained much colloid. From an examination of these thyroid glands it would, I believe, be impossible to say whether this condition would be likely to persist or not, and the probability seems to be that the process does not progress, for in not a

single case of the older fœtuses examined were any cysts found of even approximately the same relative size.

Fig. 36.—Cystic thyroid gland from a sheep fœtus, 9·8 cm. long. Actual size of section $1\frac{3}{4} \times 4\frac{3}{4}$ mm.

9. An Exceptionally Symmetrical Horseshoe Kidney lying Dorsal to the Vena cava in the Cat.

The specimen shown in the accompanying illustration was received through the courtesy of Mr John Edwin Paulson, one of our students. It is interesting particularly because of its (1) regularity in form and almost perfect symmetry, (2) because of the absence of any intermediate portion which might justly be termed an isthmus, and (3) because it lies dorsal to the vena cava. A further point of interest might be the fact that it was observed in the cat, for none of the veterinary journals accessible to me mention such an anomaly. Nevertheless one would, to be sure, expect it to occur.

The fused renal mass is located at approximately the usual level, but lies directly ventral to the vertebral column, its mid-point lying a little to the right of the median line. The superior right free pole lies several millimeters farther cranially than the left. The dorsal surface is even and flat, and there is no indication of lobulation anywhere. Since the line of fusion of the inferior poles is displaced a few millimeters to the right, the two halves are almost exactly equal in size and also symmetrical. Their total volume is, however, apparently somewhat smaller than the combined volume of normal kidneys, but there are no signs of gross pathological lesions.

The vena cava, which lies ventral to the kidney, crosses it a trifle to

the left of the median line. Both renal veins are so short that the kidney can be regarded as being sessile on the vena cava. A single renal artery, which arises from the aorta about half a centimeter cranial to the kidney, runs ventro-caudally, entering the incisure between the free cranial poles and bifurcating near the ventral surface to form two very short right and left renal arteries. The unpaired renal artery also gives rise to an unpaired ovarian artery, which lies ventral to the kidney and bifurcates opposite the cranial border of the fused inferior poles, forming the respective ovarian

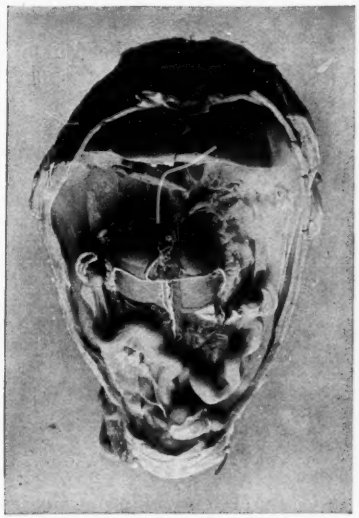


FIG. 37.—Horseshoe kidney in the cat.

arteries. There are, however, two ovarian veins. The left joins the vena cava just caudal to the kidney, and the right just opposite the free left pole directly opposite the left adrenal vein. Both adrenals, which are only about two-thirds normal size, are directed ventro-dorsally and lie against the cranial surface of the free left pole. There are two independent ureters, which lie ventrally, as is customary, and pursue practically a normal course.

In a recent contribution and review of the literature on horseshoe kidneys in man, Legueu and Papin (1) mention the fact that the dorsal surface of the fused kidneys is always grooved by the vena cava and aorta, but they do not mention the possibility of the vena cava lying ventrally, and none of their many illustrations show it in this position.

(1) LEGUEU et PAPIN, "Le rein en fer cheval," *Rev. de Gyn.*, t. xviii., 1912.

THREE EXAMPLES OF A RIGHT AORTIC ARCH.

By Douglas G. Reid, M.B., Ch.B. Edin., B.A. Trin. Coll. Camb., *Demonstrator of Anatomy in the University of Cambridge.*

Cases in which there is persistence of the fourth right aortic arch are, of course, very well known.

Nevertheless, in the cases here recorded, which occurred in adults, presented no fibrous remnants of a left aortic arch, and were not associated with transposition of the viscera or any marked cardiac anomalies, there are certain points which appear worthy of note.

Unfortunately, a number of structures had been cut before I saw the specimens.

In Cases II. and III. (see figs. 2, 3) the aortic arch, as it passes backwards on the right side of the trachea, lies just above the right bronchus.

In Case I., however, it is placed at a considerable distance above the bronchus (see fig. 1). In this specimen the highest point of the arch lies 1 cm. below the upper border of the body of the first dorsal vertebra.

The aorta ascends through the superior aperture of the thorax into the root of the neck, and must have given rise to marked suprasternal pulsation.

But in Case I., as in Case III., and as in most cases of right aortic arch (Allen Thomson and Turner), the left subclavian artery arises posteriorly, and the left common carotid is the first branch of the arch (see figs. 1, 3).

In Case I. it arises in front and to the right of the trachea, is still anterior to this at the level of the presternal notch, and must also have given rise to marked pulsation in this situation.

It is noteworthy, therefore, that suprasternal pulsation, even when most marked, may not always indicate the presence of an aneurism, and other physical signs may help to show this.

However, it seems worth while revising the causes to which attention has now been drawn, apart from aneurism, of suprasternal pulsation.

(1) An aortic arch which ascends to the level of the presternal notch.

This may or may not be due to the persistence of a more primitive position.

Poirier states that "il n'est pas rare chez les sujets âgés de voir la crosse.

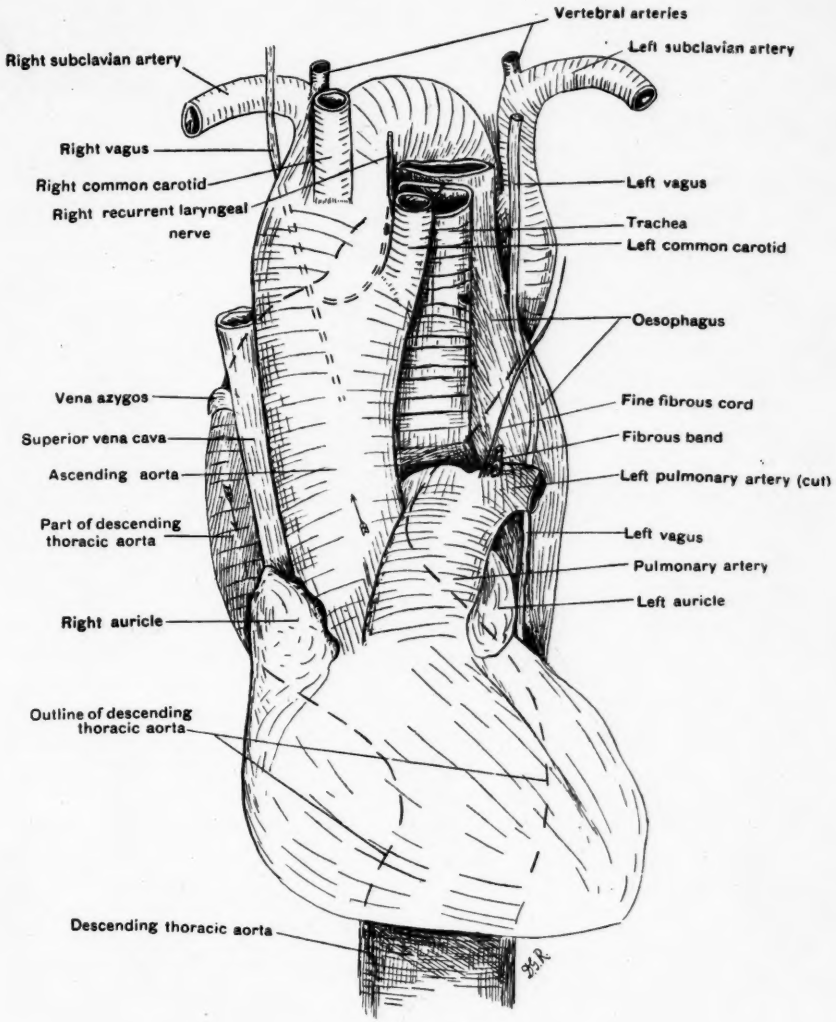

Vertebral arteries
Left subclavian artery
Right subclavian artery
Right vagus
Right common carotid
Right recurrent laryngeal nerve
Left vagus
Trachea
Left common carotid
Oesophagus
Vena azygos
Fine fibrous cord
Superior vena cava
Fibrous band
Ascending aorta
Left pulmonary artery (cut)
Part of descending thoracic aorta
Left vagus
Pulmonary artery
Left auricle
Right auricle
Outline of descending thoracic aorta
Descending thoracic aorta

FIG. 1.—Case I.

de l'aorta battre dans la dépression sus-sternale—en raison du développement du grand sinus."

(2) Abnormally situated branches of the aortic arch.

(*a*) A right (or left) innominate artery[1] "may divide higher than usual, and may then incline abnormally to the left, mounting in front of the trachea above the sternum" (Morris's *Anatomy*).

(*b*) The right subclavian, when its place of origin is to the left of the middle line (Hutchison and Rainy, *Clinical Methods*).

(*c*) The left common carotid in certain cases of right aortic arch, as I have indicated.

(3) The thyroidea ima, whose pulsations one sometimes sees as well as feels.

In Case I. the pulmonary artery, 2 inches long, lies in its usual situation, and divides, as normally, a little below, in front of and to the left of the bifurcation of the trachea, and in front of the root of the left bronchus (a relation never mentioned in the books).

The serous pericardium had been removed, and one could not determine the height to which it had ascended.[2]

In Case III., as in the case described by Allen Thomson (*Glasgow Medical Journal*, vol. xi., April 1863, p. 1), in which both aortic arches apparently had remained patent throughout until a relatively late period of intra-uterine life, and in which there was a left innominate artery, the posterior part of the arch and the upper part of the descending aorta presented a dilated portion. This is placed behind the œsophagus, and corresponds to the pouch-like trunk in Turner's ordinary case of right aortic arch.[3]

It sends forward a projection which lies to the left of the trachea, gives origin to the left subclavian artery, and terminates in a truncated extremity to which, at the root of the subclavian (see fig. 3), the ligamentum arteriosum, round which the left recurrent laryngeal nerve hooks, is attached.

Therefore in this specimen the trachea and œsophagus are almost completely encircled by the aorta.

Allen Thomson and Turner first pointed out that this dilatation which lies

[1] In old people this artery (Poirier) terminates "plus haut, au niveau du bord supérieur de l'extrémité sternale de la clavicule."

Annandale demonstrated that the innominate artery may be compressed by a finger introduced behind the upper border of the sternum.

[2] Normally the serous sac of pericardium, as Poirier points out, ascends to the back of the root of the innominate artery, and therefore into the superior mediastinum. The text-books overlook this important point. The student, when asked the contents of the superior mediastinum, always omits the serous pericardium and the azygos vein (whose arch reaches "à la hauteur de la 4e ou de la 3e vertèbre dorsale" (Poirier).

[3] *British and Foreign Medical Review*, 1862, vol. xxx.

behind the œsophagus is to be regarded, not as secondary, but as representing a persistent left aortic root (*i.e.* a portion of the left dorsal aorta caudad to the dorsal extremity of the fourth left aortic arch).

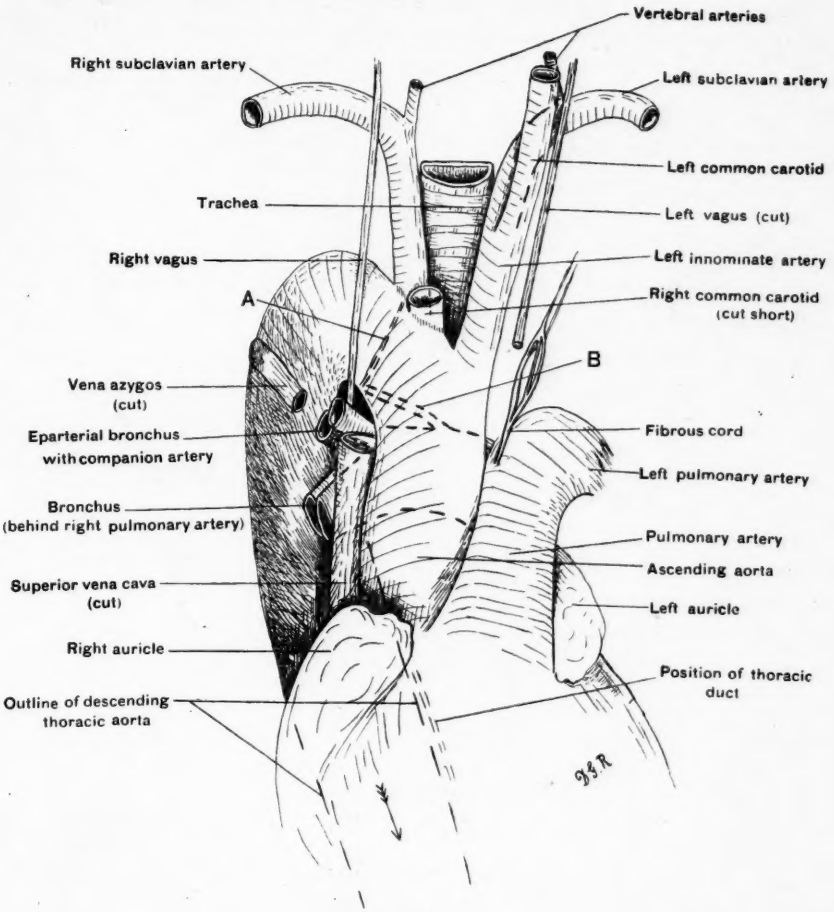


FIG. 2.—Case II.

In Case I. the aortic arch itself curves quite distinctly inwards behind the œsophagus. Its posterior part, and the commencement of the descending aorta (which lies behind the œsophagus) are also somewhat dilated, but there is no distinct projection as in Case III., and the subclavian artery

arises more directly from the arch. The aorta extends distinctly beyond the left margin of the œsophagus, and produces a deep groove on the medial surface of the left lung above the hilum.

Apparently in association with the unusual height to which the aortic arch ascends, the upper aortic intercostal arteries are much less oblique

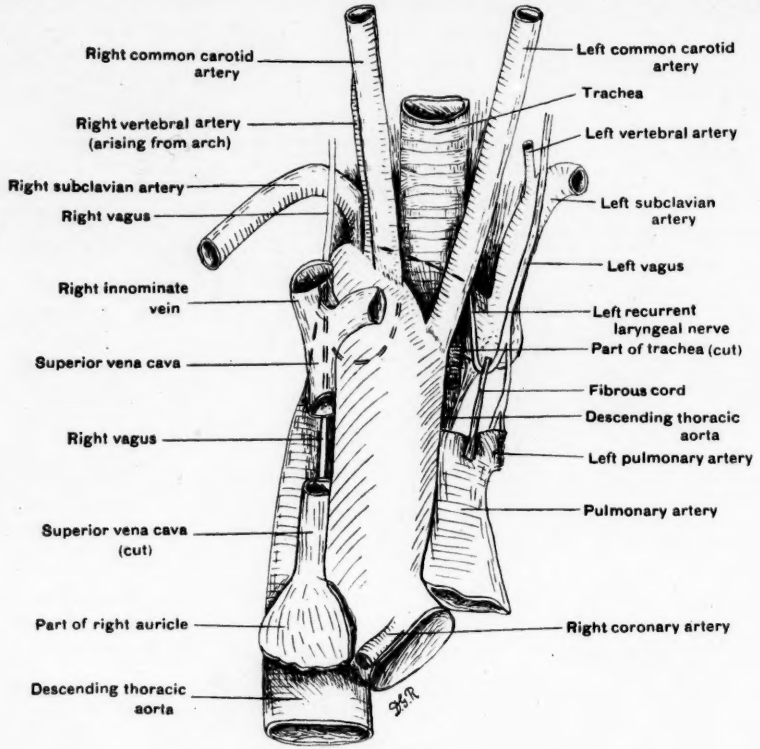


FIG. 3.—Case III.

than is usually the case. The descending thoracic aorta (the abdominal aorta had been removed) is remarkably sinuous.[1]

Above, it lies to the left of the middle line, but, taking a curved course, it comes to lie entirely to the right of the middle line and produces a deep

[1] Another case of right aortic arch with persistence of the left aortic root, as in this case, and sinuosity of the descending aorta, is recorded by Annan (*Journal of Anatomy and Physiology*, vol. xliv. p. 241). As in this case, there was no scoliosis. The presence or absence of atheroma is not noted. Atheroma was present in my specimen.

depression behind the hilum of the right lung. Below this level it regains a position to the left of the middle line, into which it comes near the aortic hiatus of the diaphragm.

In Case II., where there is a left innominate artery (partial persistence of the fourth left aortic arch) and no trace of the left aortic root, the descending aorta as it passes downwards inclines gradually to the left and forwards to reach the middle line close to the hiatus.

Little regard has been taken of the relations of the thoracic duct in cases of a fourth right aortic arch, and even Garnier and Villemin, in a recent and detailed description of a right aortic arch in a fœtus,[1] omit to mention the duct.

Allen Thomson, however, states that in his case it lay on the right side of the descending thoracic aorta, between it and the azygos vein, and joined the angle of union of the right jugular and subclavian veins.

But in Case II. the duct, except near the aortic hiatus of the diaphragm, where it lies behind the aorta, is placed on the left side of the descending aorta in front of the left intercostal arteries. Above, it passes towards the right jugular-subclavian confluence, but unfortunately its upper end had been cut by the dissectors.

In Case III. there is no duct to be found.

In Case II. a portion remains which lies in front of the left intercostal arteries, behind the parts of the aorta which lie to the left of the middle line, but to the left of the intervening portion opposite its concavity (see fig. 1). "In human embryos the observations on the thoracic duct are still scanty."

In Case III. the fibrous cord (ligamentum arteriosum) which passes from the pulmonary artery to the aortic root, and round which the left recurrent laryngeal nerve hooks, has already been mentioned.

In Case II. there are two fibrous cords. One (see fig. 2, B), a stout band, is attached to the right pulmonary artery 15 mm. from its origin, and passes to the right and upwards to a point on the inferior aspect of the aortic arch. The right recurrent laryngeal nerve (fig. 2, A) takes origin opposite this point, and comes into contact with the right extremity of the band.

The other arises from the pulmonary trunk, and divides into a number of distinct cords. In Case I., in addition to a stout band, a fine cord is present; and both are attached to the pulmonary artery close to one another.

It was unfortunate that only the parts shown in the figures had been left by the dissectors.

[1] *Bibliographie Anatomique*, vol. xix. p. 277.

A consideration of the points of attachment of these fibrous remnants of the sixth (pulmonary) arches would indicate that in Case II. a distinct portion of the right pulmonary artery was formed by the sixth right aortic arch, as is normally the case according to Bremer.[1]

The arrangement in Case I. may indicate that the pulmonary arches have fused (a fusion is described by Bremer) up to the points of origin of the pulmonary arteries, and, in view of the very plastic nature of the embryonic arteries, a variation such as this is not surprising.

In Case II. it would appear that the left sixth arch had remained patent until a relatively late period of intra-uterine life.

In cases of right aortic arch with persistence of the left aortic root (fig. 1) the presence of a fibrous remnant representing the right pulmonary arch has hitherto escaped observation.

It would appear from the presence of two distinct cords in Case I. that both pulmonary arches had remained pervious until a relatively late period, although the left may be the one which usually remains patent until birth.

I am not aware that the presence of the fibrous remnants of both sixth aortic arches has hitherto been recorded.

The relations of the other parts are accurately represented in the figures.

It will be seen that the vena azygos major (vena azygos) does not present its usual direct relation to the trachea, the aortic arch, of course, intervening. The right vagus nerve is also separated from the trachea by the aorta. In cases like III. and I. the recurrent laryngeal nerves come into close relation with the trachea at practically the same level.

In Case II. the vena azygos lies in contact with the posterior aspect of the descending aorta, and takes a course exactly parallel to it. But in Case I. this vein, like the thoracic duct, is not curved in conformity with the aorta.

Although the question as to what influence the atheroma in Case I. had in producing the sinuosity is to be kept in mind, the occurrence of sinuosity in two cases in which there was a left aortic root along with the right aortic arch suggests that the condition may be of developmental origin.

[1] Rathke held that in mammals both pulmonary arteries arose primitively from the sixth left aortic arch.

Bremer's recent papers (see the *Anat. Record*, 1909, vol. iii., No. 6, p. 334) indicate that in man the pulmonary arteries arise, one from the right and the other from the left sixth arch, which, however, never (?) forms a definite part of the left pulmonary artery.

His had already stated that primitively a pulmonary artery arises from each sixth arch, but that later both spring from the sixth left arch.

Turner, from the consideration of a case described by Breschet, also specially pointed out (in 1862) that in man the pulmonary arteries might arise one from each sixth arch.

In such cases, on the other hand, the presence or absence of correlated variations of neighbouring structures is noteworthy. Thus there was no corresponding sinuosity of the thoracic duct, although the duct, of course, is related closely to the aorta during development.

In cases of right aortic arch, that relation of the thoracic duct to which I have drawn attention, viz. its presence on the left side of the descending thoracic aorta, also appears worthy of special notice, and suggests that primitively there is a more symmetrical arrangement of the lymphatic channels than is at present known to exist.

MEASUREMENTS ON A HUMAN EMBRYO 30 MM. LONG.

By FRANK E. BLAISDELL, sen. (*From the Division of Anatomy of the Department of Medicine of Stanford University.*)

THE present observations are based on an imperfect human embryo obtained without data. They constitute an inquiry into the relative size of organs and the degree of development attained in this embryo, measuring 30 mm. from vertex to breech after fixation in alcohol.

So far, embryological measurements have been confined to external measurements, and it does not seem improbable that a series of careful measurements on the chief internal organs may form a far better criterion for estimating the age of embryos. It is to be hoped that a group of embryos of approximately similar external size may be subjected to corresponding measurements, with the idea of securing such a basis and of throwing some light on the rate of development in the various viscera, in the same and in different embryos.

CONDITION OF THE EMBRYO.

The posterior parietal and anterior cervical regions, portions of the abdomen and lower extremities, were lacerated. The injury to the head had involved the lateral wall of the occipital portion of the right cerebral hemisphere. All of the other parts of the body were perfect and in excellent condition. The embryo, which is apparently normal, is No. 9 of the collection.

METHOD OF PREPARATION.

The embryo was fixed in alcohol, embedded in paraffin, and cut serially for class work. The head was cut sagittally and the body transversely. One-half of the head, as cut, constitutes a sagittal series of one hundred and ninety-five sections (Series 9). From the transverse series of the neck and thorax twenty-five sections were selected from different levels, and these constitute Series 9A of the collection. The sections were cut 16 micra in thickness. Both series were stained with Mallory's connective-tissue stain.

Measurements and Age of the Embryo.

The damaged condition made it necessary more or less to approximate the length of the lower extremities. According to Mall's method of estimating the standing height, the measurements for Embryo No. 9 are as follows:—A vertex-breech length of 30 mm., a hip-knee (*hk*) length of 3·0 mm., and a knee-heel (*kh*) length of 6·0 mm., with a standing height of 39·0 mm. The head of No. 9 is somewhat large in proportion to the body, the upper extremities are flexed, and the forearm and hand lie transversely across the thorax; the arms are placed somewhat vertically in relation to the antero-lateral thoracic wall, with a well-marked bend at the elbows. The fingers are all free. The eyelids are completely closed and adherent. It is evident that the embryo is older than its size indicates. Unfortunately, the lack of a menstrual history prevents any discussion of the question from that standpoint, and recourse must therefore be had to a comparison with embryos of a known age and development. Probably 32 mm. vertex-breech measurement is nearer the truth, and the age about seventy days.

The measurements made from a median sagittal section of the head of No. 9 are as follows:—The diameter on a plane cutting a point between the occipital cartilage and atlas to the anterior nasal spine is 10·0 mm. The greatest cephalic diameter, which lies parallel to this line, measures 12·5 mm., while a line drawn at right angles to the first gives the height of the head as 11·0 mm. The height, as measured from the occipital cartilage at the anterior margin of the foramen magnum to the vertex, is 12·5 mm. The transverse diameter through the shoulders just cephalad to the margin of the cartilaginous manubrium and close to the articulationes humeri was 10·0 mm., and the sagittal diameter in the same plane 6·5 mm. The transverse diameter of the thorax, on a plane through base of the heart, 9·5 mm.; and the sagittal diameter in the same plane, 8·0 mm. The transverse diameter of the thorax on a plane through the mammary anlagen was 9·5 mm., and the sagittal diameter in the same plane 7·5 mm. The length of the forearm and hand, measured from a point over the cartilaginous olecranon to the tips of the fingers, 7·0 mm.

All micrometrical determinations have been made with a Zeiss ocular micrometer.

Derivatives of the Epiblast.

Epidermis.—Embryo No. 9 exhibits considerable variation in the thickness of the epidermis. In the region of the scalp the epidermis is two-layered, and one or both layers are absent in places, showing that they

are easily detached. The peridermal cells are fusiform, and here and there two cells deep. The cells of the stratum germinativum, which have nuclei somewhat centrally placed, are short and cuboidal, varying more or less in form from mutual pressure. In the lateral pectoral region, and especially lateral to the mammary region, the epidermis is distinctly two-layered, with larger cells than those on the scalp. Over the dorsal and anterior thoracic regions the stratum intermedium is present. Here the peridermal cells are fusiform in places and seem thicker, but there is so much denudation that it is hazardous to make a positive statement. Over the brachium the basal cells are rather more columnar than cuboidal. This is especially true medially where they are distinctly columnar, with nuclei apically situated. Over the face, mammary region, forearm, and hand, the stratum

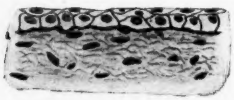


FIG. 1A.—Integument of the right side, lateral to the mammary region. Nuclei in the undifferentiated corium very sparse. Outlined with the aid of the camera lucida. B. & L., oc. 1½ in.; obj. ⅛ in. Reduced ½.

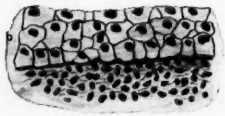


FIG. 1B.—Integument of the right mammary region, slightly lateral to the mammary anlagen. Outlined with the aid of the camera lucida. B. & L., oc. 1½ in.; obj. ⅛ in. Reduced ½.

Note.—A Zeiss microscope has been used, except when otherwise stated. Tube length of 15, and the drawing surface raised 30 mm. above that of the table.

intermedium is well developed. The cells of the superficial stratum are larger, thicker, with straighter sides and larger oval nuclei. It is difficult, however, to judge the proper focal plane, for the cells are transparent and the picture changes with the focal plane. Hence an endeavour has been made to judge and consider only the cell layers where the line of sectioning has fallen perpendicular to the surface. Commencing just above the supraciliary region, the epidermis becomes three and four cells thick, especially in the region of the mouth. On the lips the cells of the stratum germinativum gradually become high columnar, the nuclei are more elongated, and closely placed to each other so as to form a regular, heavily stained nuclear line, all these characteristics becoming more prominent as the buccal walls are approached. The same structural characteristics are present in the basal layers or stratum germinativum between the adherent palpebræ, as well as on the volar surface of the hands, where the nuclei are very deeply stained.

Derivatives of the Epidermis.

Hair germs are present in the supraciliary region, upper and lower lips, but not elsewhere on the head. The incomplete series of sections of the neck and thorax contain none in those regions.

Fig. 2 shows the degree of development reached by the hair germs. A very few may possibly possess a slight kiln-like arrangement of the cells, but since they are heavily stained the exact details are obscured. Several of the hair germs have an aggregation of heavily stained nuclei in the corium in close proximity to them. These aggregations represent differentiating papillæ. Section 49, from which the camera lucida tracing was made (fig. 2), shows the basal cells of the epidermis in the supraciliary region to be of the high columnar type. Such a pronounced columnar

Fig. 2.—Sagittal section of two hair germs in the right supraciliary region. At (*a*) the line of sectioning is through the side of a germ. Drawn with the aid of the camera lucida. Series 9A, section 49. B. & L., oc. 1 in.; obj. $\frac{1}{8}$ in. Reduced $\frac{1}{2}$.

form may be due partly to an obliquity of sectioning, although other sections do not show evidence of this. At (*a*), fig. 2, a germ is cut through the side and the nuclei of the stratum germinativum immediately adjoining are shown as assuming a straight course. It has not been possible to count all the hair germs in the supraciliary region, but as many as forty-three have been counted and numerous others in earlier stages of development are present.

Mammary Anlagen.—The mammary anlagen are more or less oval in outline. The right gland consists of two closely approximated divisions. The maximum diameter of these divisions measured transversely is 166·5 micra, and the depth to which they penetrate the mesoblast, as measured from the epidermal surface, is 216·4+ micra. The thickness of the overlying epidermis is 24·2+ micra. The formation of a connective-tissue sheath is indicated by the condensation of the surrounding mesenchyma and the crowded state of the nuclei. Fig. 1 shows the abundance of the latter, as

contrasted with their sparseness in the undifferentiated corium lateral to the mammary region.

A differentiated corium and tela subcutanea are not yet discernible. The connective-tissue reticulum is made up of fine delicate fibrillæ, and the deep surface of the developing glands with their enveloping sheaths rest upon a stratum of wavy parallel fibrillæ, that are more condensed and heavily stained. The latter is the developing pectoral fascia. The mesenchymal tissue in the vicinity of the glands has a much greater depth than at some distance from it.

Lacrimal Apparatus.—The lacrimal apparatus consists of solid epithelial cords.

The lacrimal canal cords end abruptly against the deep surface of the conjunctival epithelium, and are therefore not in continuity with it. In

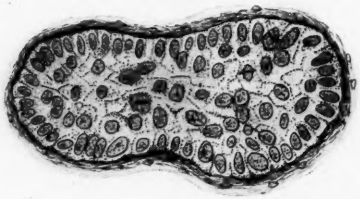


FIG. 3.—Section through the point of junction of the lacrimal cords with the nasolacrimal cord. Camera lucida drawing. Oc. 3; obj. E. Reduced ½.

all sections of the series a distinct and rather heavily stained line marks the basal line of the conjunctival epithelium. Both lacrimal cords are largest where they are in juxtaposition to the conjunctival epithelium, their diameter being 68·1+ micra. From that point each gradually diminishes to 45·4+ micra opposite the medial border of the lacus lacrimalis, again to increase in size as their junction with the nasolacrimal cord is approached, the diameter of the superior cord being 48·4+ micra, and that of the inferior 53·0+ micra. The average diameter of the nasolacrimal cord is about 61·0+ micra. That portion of the cord which corresponds to the position of the lacrimal sac has a diameter of 60·6+ micra, which increases to 75·7+ micra; thence the diameter decreases to 42·4+ micra as the cord enters the nasolacrimal canal, to increase again to about 54·5+ micra as the nasal epithelium is approached.

The central cells of the lacrimal and nasolacrimal cords have stained less strongly than the peripheral cells, but there is no distinct evidence of their degeneration to form a lumen. Fig. 3 is a camera lucida drawing of

a section through the point of junction of the lacrimal cords with the naso-lacrimal cord. In the cords the nuclei of the basal cells are slightly more elongated than elsewhere, and placed more closely and regularly, so as to form a more or less regular line. The nuclei of the intermediate and centrally placed cells are more oval. The basal part of the peripheral and more or less columnar cells shows as a narrow, clear, and unstained line. The regular row of elongated nuclei of the basal cells shows most plainly in the thickened distal extremities of the lacrimal cords just where they approach the conjunctival epithelium.

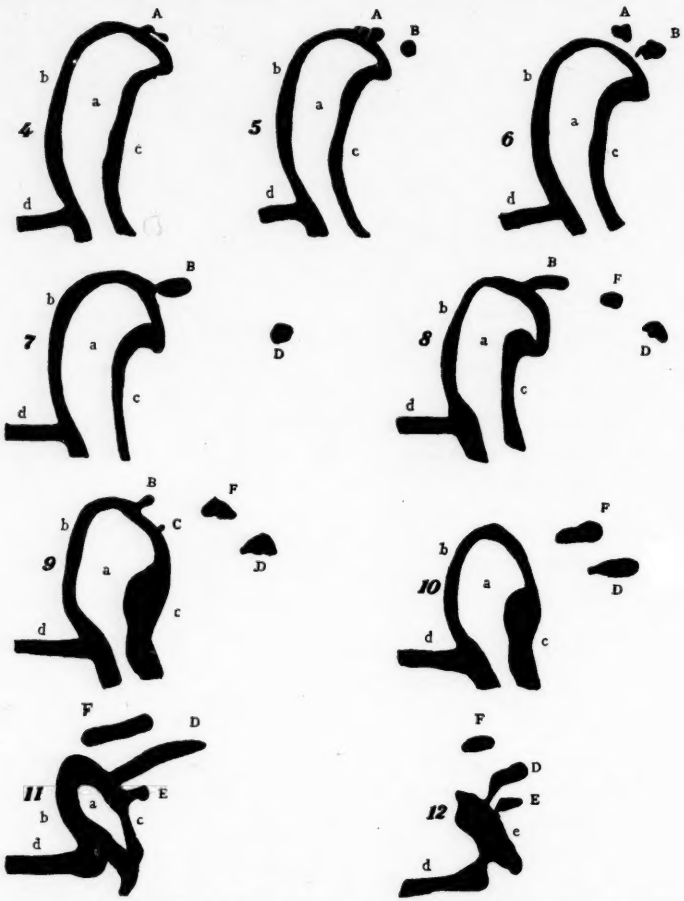
The mesenchymal tissue immediately surrounding the cords has undergone considerable condensation and differentiation to form a sheath. This sheath is less evident in the palpebral mesoblast, where there is a general condensation with a marked increase in the number of nuclei.

The nasolacrimal cord passes downward between the centre of ossification for the superior maxilla and the lateral wall of the cartilaginous nasal capsule. At the superior extremity of the developing lacrimal groove, the centre of ossification of the lacrimal bone is in contact with the nasal capsule. The nasolacrimal cord is surrounded by a thin sheath of condensed mesenchyma, and the accompanying blood-vessels are sufficiently abundant in the mesoblast occupying the pathway of the nasolacrimal canal.

The conjunctival sac in sagittal section appears as an arcuate space between the palpebræ and the bulbus oculi. The greatest distance between the superior and the inferior fornices is 1.6+ mm., the measurement having been made in a straight line between the two points named. At the internal angle of the sac, the rudimentary semilunar fold, which has a mesoblastic core, projects inwards to the distance of about 52 micra. The cells of the palpebral and bulbar conjunctival epithelium possess spherical nuclei, which lie about three deep. However, the outlines of the cells are not evident, and the basal layer does not form a regular row. The basal layer of columnar cells so evident in the inter-palpebral epithelium passes quickly into low columnar, then cuboidal, and becomes lost as a distinct layer after attaining the conjunctival surface of the palpebræ. At many points and in different sections the epithelium appears to be from four to six layers deep, but this thickness is undoubtedly due in part to an obliquity of sectioning.

Lacrimal Glands.—The anlagen of the ducts of the right lacrimal gland are six in number. The epithelial cords have grown dorsad and somewhat laterad into the mesoblast, from the superior and lateral angle of the conjunctival sac. The longer cords are slightly tortuous, and the longest one has penetrated the surrounding mesenchyma to a distance of 482·8+ micra from the surface of the conjunctival epithelium (fig. 8, D, and

13). The longest cords are lateral in position, and exhibit the most irregularity and curve medialward (cords D and F, figs. 7, 8, 9, 10, 11, 12).



FIGS. 4–12.—Diagrammatic camera lucida drawings of serial sections, showing the anlagen of the ducts of the glandula lacrimalis dextra. The order given is medial to lateral.

a, saccus conjunctivalis ; *b*, epithelium tunicæ palpebrarum ; *c*, epithelium tunicæ bulbi ; *d*, epithelium interpalpebrale ; *e*, epithelium fornicis lateralis.

Cord F is not shown to join the conjunctival epithelium, and this fact strongly suggests the loss of a section at that point. The smallest cords

are more medial as a rule. Cord B, figs. 8 and 13, has a diameter of 48·4+ micra. In the cords that have been cut longitudinally, the central cells are clearer and sparser than those at the periphery. Cord F, fig. 12 (section 128), shows a well-marked line bounding the apical surfaces of the medial layer of the peripheral cells, which are at least two layers deep. The central part of this cord has a homogeneous and hyaline appearance, with an apparent coagulum which has stained more or less deeply. The conjunctival epithelium is compact and in continuity at the point of junction with the cords.

The surrounding mesenchymal tissue is condensed and crowded with nuclei, but there is no evidence of a distinct differentiating sheath. As

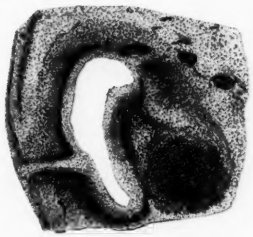


FIG. 13.—Sagittal section through the anlagen of three cords of cells of the right lacrimal gland.

FIG. 14.—Drawing of a reconstruction of the developing parotid gland. Reduced ½.

D, ductus parotideus; 1, 2, 3, primary rami; *a*, *b*, *c*, *d*, *e*, secondary divisions or buds.

usual, a heavily stained line marks the basal attachment of the cells to the mesoblast. Most of the cords have shrunken away from the surrounding mesoblast, leaving a clear and unstained space between the two, which is crossed by fine fibres connected with the base of the epithelial cells. Nerves and capillary blood-vessels are present among the anlagen, which fig. 13 shows in greater detail. A nerve is in close proximity to cord D (*vide* fig. 8).

Crystalline Lens.—In sagittal section, and as it appears in the series of sections, the lens is regularly oval in outline. Its antero-posterior diameter is 731·2+ micra, and its vertical diameter 877·5 micra. At the anterior pole the epithelium is about one-fortieth of the antero-posterior diameter of the lens, or 18·1+ micra.

Parotid Gland.—The parotid gland has been reconstructed (fig. 14) after the methods of Schaffer and Born. It is less developed than the submaxillary glands, for they have well-developed connective-tissue sheaths

surrounding the ducts and acini, and as a whole stand out distinctly among the other and less conspicuous structures (fig. 16).

The parotid gland arises from the buccal epithelium. In embryo No. 9 the epithelial cord can be followed laterad to the masseter, around which it curves, being in close relation with it. Just after leaving the lateral border of the muscle a division into what may be termed its three primary rami takes place, and these in turn possess buds which represent secondary divisions. Ramus 1 (fig. 14), which is the oldest, or perhaps more correctly a direct continuation of the main cord, lies exceedingly close to the carotid artery at its distal extremity; but it does not come in contact with it, nor with any of its larger branches. The veins occupy a similar relation, and the adult relationship has not yet become apparent. The course and relations of the cylindrical cord and its divisions may best be indicated by considering it in four portions as follows:—

1*st*. It is straight for a very short distance as it passes laterad from the buccal epithelium and beneath the external maxillary artery.

2*nd*. Then follows a very slightly tortuous portion as it passes through the buccal mesenchyma to the medial margin of the masseter.

3*rd*. It then arches across, passing external to the masseter to its lateral margin.

4*th*. The final portion enters the region between the masseter and the ramus of the mandible medially and the external auditory meatus laterally. In this portion division and budding occur, producing the various rudimentary ducts and acini. The mesenchyma, which immediately surrounds the duct, has become condensed, and later forms the connective-tissue elements of the duct and sheath. This differentiation is most evident at the proximal end of the duct and gradually less so to the point of ramification; for the fourth portion is surrounded by undifferentiated mesenchymal tissue. To be sure, changes are going on in the mesoblast, but none are recognisably concerned in the development of the sheath of the gland.

Where the duct leaves the buccal epithelium it has a diameter of 69·6+ micra, with a lumen 23·1+ micra. Fig. 15 represents a transverse section of the duct where it approaches the masseter; although the section is very slightly oblique, it gives a correct picture of the relative proportions of the walls to the lumen. The lumen is closed in the superficial portion of the buccal epithelium, for it can be traced only partly through it. Just before the primary divisions the duct has a diameter of 45·4+ micra, and the lumen, although less sharply defined, because more or less filled with broken-down cells, can nevertheless be traced into the rami as far as the buds. The epithelial cells, forming the walls of the duct and its divisions, are irregular in outline and possess large nuclei. Fig. 15 shows that the

basal cells are not arranged in a regular layer, and do not exhibit any evident differentiation. Their bases are marked by a heavily stained line. Since the epithelial rami have shrunken away from the surrounding mesoblast to a greater or less extent, a clear unstained interval separates the two. This space is crossed by very fine strands, some of which are incomplete and project from the mesoblastic surface or from the bases of the peripheral epithelial cells. Ramus 1 (fig. 14) has a diameter of about 45·4+ micra at base, and a distinct lumen 9·0 micra in diameter. Ramus 2, which also has a distinct lumen, has a diameter of 45·4+ micra. Ramus 3, which is probably the youngest of the three, has a diameter of 48·4+ micra at the base, the only point where it possesses a lumen. Bud *a*, which has

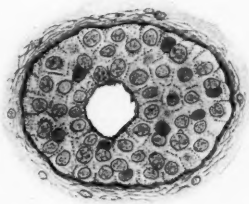


FIG. 15.—Transverse section of the ductus parotideus. Oc. 3; obj. E. Reduced ½.

FIG. 16.—Section of the submaxillary gland. Oc. 3; obj. A. Reduced ½.

no lumen, has a diameter of about 62·1+ × 81·8+ micra at the middle, and 34·8+ micra at the base. Bud *b* has a very narrow base. Bud *c*, which is 68·1+ micra in diameter at the base, is large, terminal, and knot-like, and apparently was beginning to develop two smaller outgrowths from its medial surface. Its greatest diameter is 106·0+ micra. Bud *d* has a much greater diameter at the base than bud (*a*), and a lumen has also apparently begun to appear.

In sections 47 to 51 a solid cord of cells, that ends blindly and has no connection with the parotid duct, is present. From its position near the medial border of the masseter, it is to be considered the branch observed by Chievitz. M'Murrich states that the significance of this structure is at present uncertain (*Human Embryology*, vol. ii., 1912, p. 348).

Submaxillary Duct.—At a short distance from the frenulum linguæ, in the floor of the embryonic mouth, the submaxillary duct has a diameter of 56·8+ micra. It has a distinct lumen 23·3+ micra in cross-section, with

walls about 16·6+ micra thick. The outlines of the cells are not evident and the nuclei are about three deep. In the four sections studied there is some variation in the relative proportions of the walls and lumen of the duct. One section shows the lumen a mere fissure with the walls practically in contact, suggesting that this condition may be accidental. With the high moist power it can be seen that the basal cells have separated from the contiguous mesenchyma, and that very fine strands pass between the two.

Derivatives of the Neural Epiblast.

Ophthalmic Cup.—The two layers of the ophthalmic cup are not in contact, but are separated by a considerable distance; the pigment layer is closely approximated to the undifferentiated chorioid as far forward as the anterior margin of the cup. The retinal layer, which becomes gradually thinner from the position of the developing ora serrata to the margin of the cup, is irregular where the ciliary processes develop later. At the periphery of the lens the retinal layer has a diameter of about 49·9+ micra, and is about four or five cells thick. The pigment of the external layer does not extend beyond the angle of the margin. This layer has a width of about 23·3+ micra. The optical part of the retinal layer at the fundus of the cup is 116·5+ micra thick where the line of sectioning is perpendicular to the surface. The pigment layer at the same place has a thickness of 12·1+ micra. The margin of the ophthalmic cup, as observed in the sections, lies at the periphery of the lens, at about the junction of its anterior and middle thirds. The length of the ciliary and iridal portions of the ophthalmic cup, as measured in a straight line from the ora serrata to the anterior margin, is about 406·2+ micra.

Optic Nerve.—The optic nerve, the vertical diameter of which is 357·5 micra, is solid and shows no evidence of its previous hollow state.

Cerebral Hemisphere.—The greatest length of a hemisphere, measured from the frontal to the occipital pole, is 9·0 mm. The thickness of the hemisphere varies according to the degree of growth and differentiation in different regions. Measurements made on the larger medial sections, where the plane of sectioning is quite perpendicular to the surface, gives the following results:—

Superiorly and at the frontal pole the thickness of the wall varies from 260 to 178·7+ micra, and similarly at the occipital pole the thickness varies from 138·1+ to 105·6+ micra. That part of the anterior olfactory lobe, from which the bulbus and tractus olfactorius are developed, appears as an evagination directed vertically downward, the apex of which is in relation with the membranous lamina cribrosa. The fila olfactoria can be

seen entering at the dorsal part of the apex. The evagination, which is 1267·5 micra long, was measured from a line cutting the base at its junction with the hemisphere. The length of the cavity is 1·0+ mm. The walls and cavity have (section No. 2, Series IX. A) the following dimensions in micra:—

	Anterior wall.	Cavity.	Posterior wall.
At base . . .	162·5	81·2+	373·7+
At middle . . .	243·7+	130·0	292·5
At apex . . .	357·5	130·0	146·2+

Ganglia of the Dorsal Roots.—The dorsal ganglia vary more or less in size and shape. In the lower cervical and thoracic regions they are situated in the intervertebral foramina.

Spinal Cord.—The twenty-five transverse sections, which constitute Series IX. A of the lower cervical and thoracic regions were selected from different levels. Four sections have been selected as best representing the degree of development in the cord. At the level of the foramen magnum it has a sagittal diameter of 1·8+ mm. (Series IX. A, section 5.)

Fig. 17, section 33, represents a section made transversely on a plane through the lower cervical region, cutting the trachea just below the larynx, the lateral lobes of the thyroid gland, and the upper part of the articulationes humeri. It is through the cervical enlargement, and shows that the myelon is nearly oval in section at that point. The surface line of the funiculi cuneati, as studied on a horizontal plane, is arcuate, and continues the line of the lateral funiculi, the latter being less arcuate in outline. On each side of the posterior median septum the funiculi graciles are very prominent, and consequently these funiculi form two ridges that are continued downward as far as the lower thoracic region at least, and there disappear. In section 33 the funiculi graciles are slightly divergent, and the re-entrant surfaces between them form an acute angle—the posterior median fissure. The surface line of the ventral funiculi is less arcuate than the dorsal, and a slight angle is evident ventro-laterally. The surface is slightly sunken just ventral to the posterior roots (fig. 17, *a*), and is most pronounced in the cervical and superior thoracic portions of the cord. The anterior median fissure is broad and rounded at the bottom. A commissura anterior is present. The central canal is large and pointed ovate in shape.

The posterior and anterior grey columns are large and have broad

connexions on each side. Across the median plane a posterior grey commissure is more or less distinct dorsal to the degenerating ependymal cells. The posterior grey columns are noticeably larger than the anterior.

The measurements of the cord are as follows (fig. 17):—

Cord—	
Sagittal diameter	1446·2+ micra.
Transverse „	1251·2+ „
Central Canal—	
Sagittal diameter	503·7+ „
Transverse „	211·2+ „
Vertebral Canal—	
Sagittal diameter	1787·5 micra.
Transverse „	1727·5 „

Fig. 18, section 48, represents a section made transversely on a plane through the base of the neck just above the cartilaginous manubrium, below the thyroid gland and articulationes humeri and through the upper part of the thymus gland. At this level the cord is less oval and somewhat pentagonal in outline. The angle at the junction of the dorsal and lateral surfaces is more marked. The sides are less arcuate, more parallel, and arch into the surface of the ventral funiculi. The surface of the funiculi cuneati is straighter and somewhat oblique, giving an ogival effect to the outline. The prominence of the funiculi graciles is about the same as at a little higher level, but the re-entrant surface between them is less acutely angled. The surface just ventral to the dorsal roots is the same as at a higher level.

The measurements are (fig. 18):—

Cord—	
Sagittal diameter	1300·0 micra.
Transverse „	1202·5 „
Central Canal—	
Sagittal diameter	471·2+ „
Transverse „	195·0+ „
Vertebral Canal—	
Sagittal diameter	1706·2+ „
Transverse „	1576·2+ „

Fig. 19, section 35, represents a section made on a plane through the atrio-ventricular orifices of the heart. At this level the cord is still more pentagonal in section. The lateral surfaces are straighter ventro-dorsally

and the surface lines but slightly arcuately re-entrant. They are marked both dorso-laterally and ventro-laterally by somewhat evident angles from the surface of the cuneate and ventral funiculi respectively. The surfaces of the ventral funiculi are arcuate, and the anterior median fissure is more acutely angular at the bottom. The dorsal funiculi are shaped about the same as at the higher level at the base of the neck, but the funiculi graciles

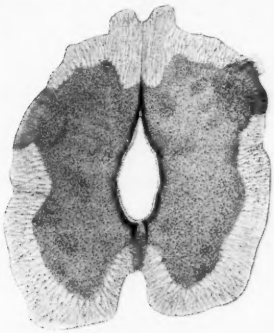


FIG. 17.

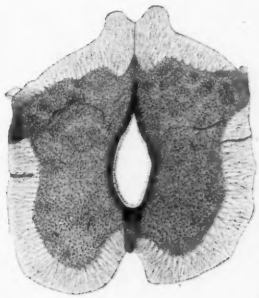


FIG. 18.

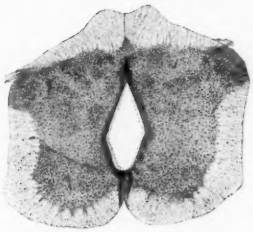


FIG. 19.

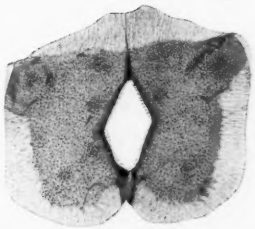


FIG. 20.

Transverse sections of the medulla spinalis, as observed under low power. × 70. Reduced to ⅓.

are less prominent; the re-entrant surface between them is correspondingly shallower and broader. The central canal is more rhomboidal in cross-section than at the level previously described. The sunken surface ventral to the dorsal roots is not noticeable, and there is still greater disparity between the grey columns.

The measurements are (fig. 19):—

Cord—

Sagittal diameter	1015·6+ micra.
Transverse „	1121·2+ „

Central Canal—
Sagittal diameter . . . . . 406·2 micra.
Transverse „ . . . . . 195·0 „

Vertebral Canal—
Sagittal diameter . . . . . 1348·7 „
Transverse „ . . . . . 1592·5 „

Fig. 20 was drawn from section 31, which was on a horizontal plane through the liver and diaphragm, at the caudal extremity of the sternum. At this level the myelon is less pentagonal and more quadrate in section. The surface lines of the lateral funiculi are straighter and more parallel; the dorso-lateral and ventro-lateral angles are marked, the latter more rounded. The surface of each ventral funiculus is arcuate from side to side, and the anterior fissure shallower and less acutely angled at the bottom. The surfaces of the funiculi cuneati are straighter on each side, and the dorsal outline less ogival. The funiculi graciles are less prominent and the intervening surface scarcely re-entrant. The central canal is rhomboidal.

The measurements are (fig. 20):—

Cord—
Sagittal diameter . . . . . 991·2 micra.
Transverse „ . . . . . 1137·5 „

Central Canal—
Sagittal diameter . . . . . 406·2+ „
Transverse „ . . . . . 219·3+ „

Vertebral Canal—
Sagittal diameter . . . . . 1332·5 „
Transverse „ . . . . . 1462·5 „

For the sake of accuracy it should be stated that the sections are not cut on a perfectly horizontal plane, but slightly diagonally. However, this obliquity is scarcely enough seriously to affect the diameters.

The lumen of the central canal has undergone considerable obliteration between the dorsal zones. The canal is also evenly curved from side to side across the floor-plate. If any angles have existed they have become obliterated, and this is a probable explanation of the deeply stained ependymal cells observed each side of a centrally located clearer area in the floor-plate.

Derivatives of the Mesoblast.

The cartilaginous skeleton is well developed and centres of ossification for the following bones have appeared:—

Clavicle.—The cartilaginous outline is already involved in ossification.

Mandible and Maxilla.—The most conspicuous centre is that for the lower border and front of the alveolar process. None of the sections show that the distal end of Meckel's cartilage is involved in the process of ossification, and there are two other small centres which have not been clearly identified. One of these may be the centre for the coronoid process. The other consists of two punctiform areas lying between and below the proximal end of Meckel's cartilage and the tympanum. A well-developed centre is present for the maxilla.

Nasal Bone.—A distinct centre lies over the cartilaginous nasal capsule.

Lacrimal Bone.—A thin delicate centre lies over the side of the nasal capsule.

Malar Bone.—Two centres are apparently present.

Frontal Bone.—Ossification is well under way in the orbital plate and lower portion of the vertical part.

There is no evidence of centres in the parietal and temporal membranes or cartilages.

The twenty-five sections constituting the selected series of transverse sections, Series IX. A, give negative results for centres of ossification in the lower cervical and thoracic regions.

Ocular Bulb.—The sclera is well defined from the surrounding orbital connective tissue. The chorioid-sclera has a thickness of 83·2+ micra posteriorly, at a point where it is sharply defined by being in contact with a rectus muscle. The fibrils of the sclera, as viewed in sagittal section, run parallel to each other, and are more or less undulating. The meshes which are elongately fusiform vary in width and size. The nuclei are elongate and have their long axes parallel to the fibrils, with which they are in close contact. In the equatorial region, at the places of muscular insertions, and in the ciliary zone as well, they become much more abundant, and a large number of them are shorter, thicker, and more oval. A moderately large vessel, probably a vena vorticosa, is occasionally present in cross-section in the sclera. No muscular tissue has yet differentiated in the ciliary body.

Cornea. — The corneal tissue is more condensed, and structurally resembles the sclera, into which it passes imperceptibly. The meshes between the fibrils are narrower. The thickness of the substantia propria corneæ is 63·6+ micra at the periphery, and 31·8+ micra at the middle. The corneal epithelium is two or three layers thick. The cells of the basal layer appear cuboidal, and the nuclei are relatively large, round, or slightly oval. The superficial cells are flattened and appear more or less fusiform in section. The epithelium has a thickness of 15·1+ micra. The sclera passes quite gradually, although somewhat abruptly, into the surrounding

orbital connective tissue. Its fibrils become farther apart, finally less parallel, with shorter and more irregular meshes.

The distance between the internal surface of the cornea and the anterior surface of the lens is about 33·9+ micra. This space is filled at the periphery with mesoblast, which disappears in the tissue of the sclera opposite the lenticular zone of the ophthalmic cup. Except for a very attenuated layer extending over the lens, and that constituting the corneal endothelium, which is 3·9+ micra thick, the mesoblast is absent centrally, leaving a space, the cavity of the aqueous humor.

The basal cells of the corneal epithelium rest upon a rather deeply stained and fine line, that marks the anterior limit of the substantia propria corneæ, but such a line is not evident at the posterior limit.

Chorioid.—The chorioid, which is not clearly differentiated from the sclera, can only be recognised by the few capillary vessels lying immediately adjacent to the pigment layer of the ophthalmic cup. These capillaries are less evident in the fundus, and are most distinct in the region of the ciliary body.

Posterior Chamber.—The internal layer of the ophthalmic cup is not in contact with the external or pigment layer, and the diameter of the vitreous chamber has not been measured. The greatest internal diameters of the eye are as follows:—the vertical diameter between the internal surfaces of the chorioid-sclera is 1·8 mm; the antero-posterior diameter, measured as nearly as possible in the optic axis, is approximately 2·0 mm. The measurement was made between the internal surface of the chorioid-sclera posteriorly and the internal surface of the corneal endothelium anteriorly.

Muscles.—The voluntary muscles are well developed, and those that are in longitudinal section show distinct striations. Much of the muscular tissue is stained either very slightly or very heavily, hence the striations could not be studied in all.

Arm.—The diameters of the cartilaginous shaft of the humerus in the middle third are 650·0 × 645·0 micra, while the transverse diameter through the epicondyles is 1·4+ mm.

Forearm.—The cartilaginous radius has a length of 3·8+ mm. The diameter of the head is 0·5 mm.

Thoracic Aorta.—The thoracic aorta is of uniform size and quite cylindrical in section. It is in close relation with the ventral surface of the cartilaginous centra of the thoracic vertebræ, being on an average about 211·2+ micra ventral to the same. The total diameter is 406·2+ micra. The lumen measures 211·2+ micra, and the walls have a thickness of 86·5+ micra.

Contents of the Carotid Sheath.—The common carotid has a diameter of 178·7+ micra, with a lumen of 76·5+ micra, and a wall of about 96·5+

micra thick. The internal jugular vein, which varies in size, measures 422·5 × 739·3+ micra, and is distended with blood. The vagus nerve, although epiblastic, may be mentioned as having a diameter of about 133·2 × 233·1 micra.

Heart.—In one of the transverse sections the heart is cut longitudinally and through the atrio-ventricular orifices. At the apex a broad and well-marked sulcus longitudinalis is present. One cusp of the tricuspid valve has a thickness of 45·4+ micra, but the others are thicker and evidently have been sectioned obliquely. The left ventricular wall has the following thickness in micra:—near the base, 227·5; at middle, 276·2+; at apex, 178·7+. Similarly for the right ventricular wall:—near the base, 260·0; at middle, 162·5; at the apex near the sulcus longitudinalis, 97·5. The septum at the middle has a thickness of 487·5 micra, being thinner near the base and apex. The above measurements do not include the trabeculæ carneæ.

Derivatives of the Mesoblast and Hypoblast.

Œsophagus.—Three tunics are recognisable in the œsophagus—an epithelial, a muscular, and an intervening connective-tissue layer. The peri-œsophageal connective-tissue tunic is slightly denser in the neck than in the mediastinum; in the latter region it is delicate, loose, and stains very lightly. The œsophagus is largest at its commencement, and gradually diminishes in diameter from above downward, to a point slightly above the bifurcation of the trachea (fig. 21, C to J), where it becomes smaller, more cylindrical, and nearly uniform in diameter and size, and continues so to the œsophageal opening in the diaphragm, the diameters being 422·5 × 455·0 micra. Just below the termination of the pharynx the œsophagus has a diameter of ¾ mm. (fig. 21, C). It is contiguous to the trachea throughout the entire length of the latter, except for a short distance opposite the lower end of the larynx and the beginning of the trachea (fig. 21, C and D). The interval of separation is about 166·5 micra wide. Fig. 21, A and B, two sections through the lower extremity of the pharynx.

The epithelium has a mean thickness of 37·3 micra. The cells of the basal layer have become distinctly columnar and are clear and unstained at their bases. The other layers of the mucosa have not differentiated from the subepithelial mesenchyma, which forms a well-marked tunic varying in thickness as a result of longitudinal folds which extend through the whole length of the œsophagus, below a point just above the bifurcation of the trachea (fig. 21, J to X). Above this point the lumen is more open (fig. 21, C to I) and the form of the œsophagus is transversely oval for a short distance, as a result of sagittal flattening (fig. 21, H and I).

Rugæ are present above a point opposite the bifurcation of the trachea. Since they are more irregular in development the lumen is more irregular in outline. The subepithelial mesenchyma, which has a mean thickness of about 81·0+ micra, is thinnest between rugæ. Opposite them the thick-

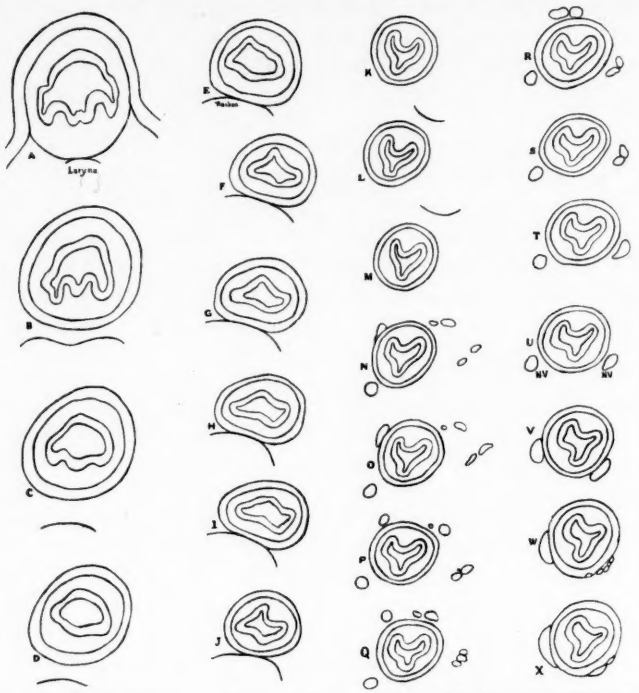


FIG. 21.—Outlines of transverse sections of the œsophagus and pharynx, at different levels, serially arranged. × 70. (Zeiss oc. 3 ; B. & L., obj. 1 in.) Reduced to ⅓.

A, through the termination of the pharynx ; B, through the transitional point ; C and D, œsophagus slightly separated from the larynx ; E to J, œsophagus contiguous to the trachea ; K, immediately below the bifurcation of the trachea ; K to M, œsophagus in relation to the aorta, beyond which point the latter is too distant to be shown in the figures ; N to X, œsophagus in relation with the nervi vagi (above N the latter is too distant to be shown) ; X, a short distance above the hiatus œsophageus.

ness is much greater, being 66·6+ and 141·7+ micra. The tunica muscularis has an average thickness of about 37·8+ micra, but is a little thicker opposite the larynx.

The lumen varies in shape in different parts of the œsophagus, and the epithelial walls are in contact nowhere. It is larger and more broadly open in the first part, where it is irregular and not affected by distinct rugæ. In the lower part of the pharynx and the beginning of the œsophagus

where it is connected to the larynx by condensed mesenchymal tissue, two distinct and well-marked parallel prominences, which project into the lumen, are present in the ventral wall (fig. 21, A and B). At the beginning of the œsophagus the lumen has a transverse diameter of about 357·5 micra (fig. 21, C); and as the œsophagus becomes more distinctly cylindrical in the region of the tracheal bifurcation, the three longitudinal rugæ become distinct. The largest is the dorsal and more or less slightly sinistral in position. The other two, which are ventro-lateral in position, are subequal, and scarcely one-half as prominent as the dorsal ruga. Consequently the lumen is tri-radiate in form as seen in transverse section; narrowest below the tracheal bifurcation, and becomes slightly larger as the diaphragm is approached.

The relation of the œsophagus to the trachea and aorta already indicates the adult condition. In determining their relative positions, a line was drawn on the camera lucida outlines of the sections, to represent the median sagittal plane passing through the anterior median fissure and the posterior median septum of the spinal cord, and the chorda dorsalis. In some sections, especially those of the upper thorax, this line cut the sternal cartilage at the middle, but lower down where some asymmetry exists it passed sinistrad to the sternum. The right side of the thorax appears slightly more prominent than the left. At the termination of the pharynx the œsophagus is directly dorsal to the larynx; lower it becomes gradually and slightly more sinistral, while still lower it appears to be in the median plane, with the trachea distinctly more dextral down to its point of division. At its beginning the thoracic aorta is sinistral to the median plane, and the œsophagus median on a plane ventral to it. That is, a frontal plane passing between the two would touch the ventral wall of the aorta and the dorsal wall of the œsophagus, which are about 0·06 mm. distant from each other. At a lower level the aorta becomes slightly more medial; the œsophagus more ventral, or rather ventro-dextral and distant. As the diaphragm is approached both are sinistral in position as regards the median plane, the œsophagus being distinctly ventral to the aorta. A short distance above the œsophageal opening in the diaphragm the œsophagus is 0·5 mm. distant from the aorta. At its commencement it lies about 341·2+ micra ventral to the vertebral column; below the tracheal bifurcation it is about 520·0 micra distant, and but a short distance above the diaphragmatic opening it is 1·1+ mm. ventral to the same.

Trachea.—Immediately caudal to the larynx the trachea is oval in section and the sagittal diameter is greater than the transverse. The oval shape may in part be due to an obliquity of sectioning, although a

short distance farther caudad it becomes cylindrical. A short distance cephalad to the bifurcation it is slightly transversely oval. Cartilaginous rings are present. It has a uniform shape between the points above mentioned. In its cylindrical portion the diameters are 633·7+ × 601·2+ micra; with a lumen of 438·7+ × 373·7+ micra, and an epithelium 22·7+ micra thick. In the transversely oval portion, just above the bifurcation the transverse diameter is 650·0 micra, and the sagittal diameter is 438·7+ micra.

Bronchi.—In sections 12 and 13, Series IX. A, the right bronchus is transversely and the left bronchus longitudinally cut. In the right bronchus, cartilages are present. The diameters are 487·5 × 325·0 micra, and that of the lumen about 268·1+ × 228·5 micra. The thickest part of the wall with the cartilage is 156·5+ micra.

In the left bronchus the cartilages disappear before the hilum of the lung. The sagittal diameter is 292·5 micra, and the thickest part of the wall with cartilage is about 111·5+ micra.

Thyroid Gland.—The greatest diameters of a lateral lobe are 568·7+ × 487·5 micra. The largest parathyroid, which is quite cylindrical in section, measures 186·4+ × 133·2 micra in diameter.

Thymus.—Both lobes taken together have a transverse diameter of 1·0+ mm., and a sagittal one of 487·5 micra. They gradually taper as they ascend into the neck to a short distance above the cartilaginous manubrium, where the apices appear equal and cylindrical in section.

List of Measurements.

Vertex to breech	30 mm.
Hip to knee	3·0 „
Knee to heel	6·0 „
Estimated standing height	39·0 „

Head.—Median sagittal section of head—

(*a*) Diameter on a plane cutting a point between the occipital cartilage and atlas, through the anterior nasal spine	10·0 mm.
(*b*) Greatest sagittal diameter	12·5 „
(*c*) Height of the head. Obtained by drawing a line at right angles to that from which (*a*) was made.	11·0 „
(*d*) Height as measured from the occipital cartilage at the anterior margin of the foramen magnum to the vertex	12·5 „

Thorax—

Transverse diameter through the shoulders just cephalad to the margin of the cartilaginous manubrium and close to the articulationes humeri	10·0	mm.
Sagittal diameter in the same plane	6·5	„
Transverse diameter on a plane through the base of the heart	9·5	„
Sagittal diameter in the same plane	8·0	„
Transverse diameter on a plane through the mammary anlagen	9·5	„
Sagittal diameter in the same plane	7·5	„

Forearm and hand—

Length from a point over the cartilaginous olecranon to the tips of the fingers	7·0	„

Mammary anlagen—

Maximum transverse diameter of the right anlage	166·5	micra
Depth to which they penetrate the mesoblast, from the surface	216·4+	„
Thickness of epidermis over the anlage	24·2+	„

Lacrimal apparatus—

The lacrimal cords, which are largest where they are in juxtaposition to the conjunctival epithelium, measure	68·1+	„
From that point each gradually diminishes to	45·4+	„
opposite the medial border of the lacus lacrimalis, to again increase in size as their junction with the nasolacrimal cord is approached, the diameter of the superior cord being	48·4+	„
And that of the inferior cord	53·0+	„
The average diameter of the nasolacrimal cord is about	61·0+	„
That portion which corresponds to the position of the lacrimal sac, has a diameter of	60·6+	„
It increases to	75·7+	„
And decreases to	42·4+	„
as the cord enters the nasolacrimal canal, and increases again to about	54·5+	„
as the nasal epithelium is approached.		
The greatest distance between the superior and inferior fornices of the conjunctival sac is	1·6+	mm.

The rudimentary semilunar fold projects into the sac to the distance of approximately . . . . 52·0 micra
The longest developing duct of the lacrimal gland has penetrated the surrounding mesenchyma to the distance of . . . . . 482·8+ „
from the surface of the conjunctival epithelium.
Cord B (fig. 14) has a diameter of . . . . . 48·4+ „

Crystalline lens—
The lens has an antero-posterior diameter of . . 731·2+ „
and a vertical one of . . . . . 877·5+ „
At the anterior pole of the lens the epithelium is about 18·1+ „
in thickness, being approximately one-fortieth of the total antero-posterior diameter.

Ophthalmic cup—
The retinal layer at the periphery of the lens has a diameter of about . . . . . 49·9+ micra
and the external or pigment layer is about . 23·3+ „ thick
The optical part of the retinal layer at the fundus is about . . . . . 116·5+ „ „
and the pigment layer . . . . . 12·1+ „
The length of the ciliary and iridal portions as measured in a straight line from the ora serrata to the anterior margin of the cup is about . . . . . 406·2+ „

Optic nerve—
The vertical diameter of the nerve is . . . . 375·5 micra

Cerebral hemisphere—
The greatest length, as measured from the frontal to the occipital pole, is . . . . . 9·0 mm.
Superiorly and at the frontal pole the thickness of the wall varies from . . . . . 260·0 to 178·7+ micra
but at the occipital pole it varies from 138·1+ to 105·6+ „

Rhinencephalic evagination—
Measured from a line cutting the base at its junction with the hemisphere at the surface has a length of 1267·5 „
The total length of its cavity as measured from a point on a line with the inner surface of the wall of the hemisphere is . . . . . 1·0+ mm.

The walls and cavity have the following dimensions in micra:—

	Anterior wall.	Cavity.	Posterior wall.
At base . . .	162·5	81·2+	373·7+
At middle . .	243·7+	130·0	292 5
At apex . .	357·5	130·0	146·2+

Spinal cord.—Measurement of cross sections in micra:—

Plane of section.	Object cut.	Sagittal.	Transverse.
At level of foramen magnum .	Cord	1·8+ mm.	
Fig. 17.—Lower cervical region just caudad to the larynx:	Cord	1446·2+	1251·2+
	Central canal	503·7+	211·2+
	Vertebral canal	1787·5	1527·5
Fig. 18.—Just cephalad to the manubrium sterni	Cord	1300·0	1202·5
	Central canal	471·2+	195·0
	Vertebral canal	1706·2+	1576·2+
Fig. 19.—Through the atrio-ventricular orifices	Cord	1015·6+	1121·2+
	Central canal	406·2	195·0
	Vertebral canal	1348·7	1592·5
Fig. 20.—Through caudal extremity of the sternum	Cord	991·2	1137·5
	Central canal	406·2+	219·3+
	Vertebral canal	1332·5	1462·5

Parotid gland—

At the point where it leaves the buccal epithelium the parotid duct has a diameter of 69·6+ micra,
with a lumen of . . . . . 23·1+ „
Just before the primary divisions it has a diameter of . . . . . 45·5+ „
Ramus 1 (fig. 14) has a diameter of about . 45·4+ „
with a lumen . . . . . 9·0 „
Ramus 2 has a diameter of . . . . 45·4+ „
Ramus 3 „ „ . . . . 48·4+ „ at the base
Bud *a* has a diameter of about . 62·1+ × 81·8+ „
at the middle, and . . . . . 34·8+ „ „
Bud *b* has a very narrow base. Bud *c* which is large has a diameter of about . 68·1+ „ „
and a greatest diameter of . . . 106·0+ „

Submaxillary duct—

The duct at some distance from the frenulum linguæ has a diameter of . . . . 56·8+ micra
with a lumen of . . . . . 23·3+ „
The walls are about . . . . . 16·6+ „ thick

Ocular bulb—

The chorioid-sclera has a thickness of . . . . 83·2+ micra
posteriorly at a point where it is sharply defined through contact with a rectus muscle.

Cornea—

The thickness of the substantia propria corneæ is . 63·6+ „
at the periphery, and . . . . . 31·8+ „
at the middle.
The corneal epithelium has a thickness of . . . 15·1+ „
The corneal endothelium . . . . . 3·9+ „
and the distance between the internal surface of the cornea and the interior surface of the lens is about . . . . . 33·9+ „

Posterior chamber—

The greatest vertical diameter between the internal surfaces of the chorioid-sclera is . . . . 1·8+ mm.
The antero-posterior diameter, measured as nearly as possible in the optic axis, is approximately . . 2·0 „
It is made between the internal surface of the corneal endothelium anteriorly and the internal surface of the chorioid-sclera posteriorly.

Arm—

The diameters of the cartilaginous shaft of the humerus in the middle third are . . . . . 650·0 × 645 micra
And the transverse diameter through the epicondyles is 1·4+ mm.

Forearm—

The cartilaginous radius has a length of . . . 3·8+ mm.
The diameter of the radial head is . . . . . 0·5 „

Thoracic aorta—

The average distance ventral to the cartilaginous centra of the thoracic vertebræ is . . . . 211·2+ micra
The total diameter is about . . . . . 406·2+ „
The lumen measures . . . . . 211·2+ „
And the walls have a thickness of . . . . 86·5+ „

Contents of the carotid sheath—

The common carotid artery has a diameter of . . 178·7+ „
with a lumen . . . . . 76·5+ „
and walls with a uniform thickness of about . 96·5+ „

The internal jugular vein, which varies in size and is distended with blood, measures . . . 422·5 × 739·3 + micra
The vagus nerve is about . . . . . 133·2 × 233·1 „

Heart—

A cusp of the tricuspid valve has a thickness of . . 45·4 + „
The ventricular walls have the following thickness in micra:
Left wall near base . . . . . 227·5
at middle . . . . . 276·2 +
at apex . . . . . 178·7 +
Right wall near base . . . . . 260·0
at middle . . . . . 162·5
at apex near the sulcus longitudinalis . . . 97·5
The interventricular septum at the middle has a thickness of . . . . . 487·5 micra
but is thinner near the base and apex. The above measurements do not include the trabeculæ carneæ.

Œsophagus—

A nearly uniform size is maintained between a point opposite the bifurcation of the trachea and a short distance above its passage through the diaphragm.
The diameters at this point are . . . 422·5 × 455·0 „
and just below the termination of the pharynx it measures . . . . . ¾ mm.
The maximum distance of separation from the trachea, at a point opposite the lower end of the larynx, is . . . . . 166·5 micra
The tunica presents the following variations in thickness:—
Epithelium, maximum thickness . . . . . 43·9 „
minimum thickness . . . . . 30·3 „
mean thickness . . . . . 37·3 „
The muscularis has an average thickness of about . 37·8 + „
The sub-epithelial mesenchyma has a minimum thickness between the rugæ of . . . . . 34·8 + „
A maximum thickness at the largest ruga of . . 141·7 + „
at the smallest . . . . . 66·6 + „
with a mean thickness of . . . . . 81·0 + „
The transverse diameter of the lumen of the œsophagus
at the beginning is . . . . . 357·5 „
and below the bifurcation of the trachea about . 199·8 „

The distance of separation from the thoracic aorta at the beginning of the descending portion is . . 95·4+ micra
and a short distance above the œsophageal opening in the diaphragm it is . . . . . 0·5 mm.
The distance of the œsophagus from the vertebral column at the beginning is . . . . . 341·2+ micra
below the tracheal bifurcation, about . . . 520·0 „
and a short distance above the opening in the diaphragm it is . . . . . 1·1+ mm.

Trachea—
In its cylindrical portion the diameters of the trachea are . . . . . 633·7+ × 601·2+ micra
and the lumen measures . . . 438·7+ × 373·7+ „
The thickness of the epithelium is . . . . 22·7+ „
Above its bifurcation the diameters are as follows:—
Sagittal . . . . . 438·7+ „
Transverse . . . . . 650·0 „

Bronchi—
The right bronchus measures . . . . 487·5 × 325·0 „
the lumen . . . . . 268·1+ × 228·5 „
and the wall with cartilage about . . . 156·5+ „
The sagittal diameter of the left bronchus is . . 292·5 „
and the wall including the cartilage is about 111·5+ micra thick

Thyroid gland—
The greatest diameters of a lateral lobe are . 568·7+ × 487·5 micra
And the largest parathyroid measures . . 186·4+ × 133·2 „

Thymus—
The transverse diameter through both lobes is . . 1·0+ mm.
and the sagittal diameter of a lobe is . . . 487·5 micra

REFERENCES.

His, W., "Normentafel," *Anatomie menschlicher Embryonen*, Leipzig, 1880–1885.
His, W., "Spinal Cord," *Abhandl. d. k. sachs. Gesellsch. d. Wiss.*, xiii., 1882.
Chievitz, J. H., "Beiträge zur Entwicklungsgeschichte der Speicheldrusen," *Arch. für Anat. und Phys., Anat. Abth.*, 1885.
Mall, F. P., "Age of Human Embryos," *Ref. Handb. Med. Sci.*, 2nd ed., iii., 1901.

Minot, Charles S., *A Laboratory Text-book of Embryology*, 1903.

Keibel and Elze, *Normentafel zur Entwicklungsgeschichte des Menschen*, Jena, 1908.

Wilson, J. T., "On the Anatomy of the Calamus Region in the Human Bulb; with an account of a hitherto undescribed 'Nucleus Postremus,'" *Journ. Anat. and Physiol.*, vol. xl., ser. 3, 1, 1905–1906.

M'Murrich, J. A., *The Development of the Human Body*, 1902.

Piersol, G. A., *Human Anatomy*, 1907.

Bailey and Miller, *Text-book of Embryology*, 1909.

Keibel and Mall, *Human Embryology*, vol. i., 1910.

Keibel and Mall, *Human Embryology*, vol. ii., 1912.

A CONGENITAL ABNORMALITY OF THE HEART AND BLOOD-VESSELS.

By W. E. Carnegie Dickson, M.D., B.Sc., F.R.C.P.E., *Pathologist, Royal Hospital for Sick Children, Edinburgh*; and John Fraser, M.D., M.Ch., F.R.C.S.E., *Assistant Surgeon, Royal Hospital for Sick Children, Edinburgh.*

An interesting specimen of congenital errors in the development of the heart and blood-vessels has come under our observation; the uniqueness of the condition seems to warrant its publication.

Clinical History.

The specimen was obtained from a male child four months old. The baby was admitted to hospital on account of persistent vomiting, which in certain respects resembled the vomiting of congenital stenosis of the pylorus. Examination, more especially by means of bismuth meals and X-rays, showed that, while there was no stenosis of the pylorus, there was a dilatation of the first portion of the duodenum. The child failed to respond to medicinal treatment, and a posterior gastro-enterostomy was performed. Some hours after operation the child collapsed and died.

In view of the cardio-vascular abnormalities which were discovered post-mortem, it is interesting to note the observations which were made upon the heart during life. The organ was found to be distinctly enlarged, the apex beat was in the sixth interspace and a finger-breadth outside the nipple line. The right border of the heart was $1\frac{1}{4}$ inches from the middle line, and the left border extended a full inch beyond the nipple line. Auscultation revealed a systolic bruit, heard most clearly in the pulmonary area; there was also some accentuation of the second sound.

Description of Specimens.

Examination of the heart showed:—

(1) The right auricle and left auricle were healthy.
(2) The ventricular portion of the heart was uniformly enlarged and hypertrophic.
(3) There was an incomplete interventricular septem.
(4) From the base of the ventricles a single large vessel was given

off (the aorta): its origin was guarded by three complete semilunar valves, and into it both ventricular cavities opened.

(5) The right pulmonary artery originated from the aorta half an inch from the commencement of the latter: the pulmonary vessel passed directly to the right lung.

(6) The left and the right common carotids originated directly from the aorta.

(7) The right and left subclavian vessels passed directly from the

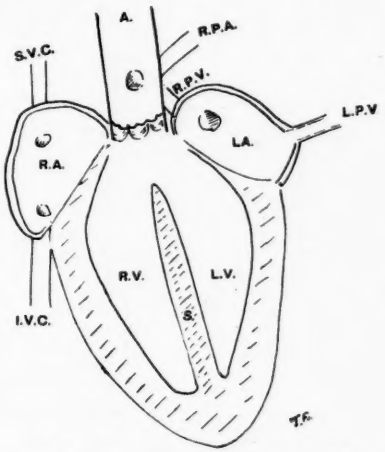


FIG. 1.—Section of heart (diagrammatic).

A., aorta; S.V.C., superior vena cava; I.V.C., inferior vena cava; R.A., right auricle; L.A., left auricle; R.V., right ventricle; L.V., left ventricle; S., interventricular septum; R.P.A., right pulmonary artery; R.P.V., right pulmonary vein; L.P.V., left pulmonary vein.

aorta, springing from just beyond the arch and passing outwards to the upper extremities behind the apices of the lungs.

(8) The left pulmonary artery originated from the descending aorta and passed outwards to the lung behind the œsophagus.

Speaking embryologically, it would appear that the development became disturbed during the third week. The points in abnormal anatomy are in keeping with—

A.—A persistence of the right and a disappearance of a considerable portion of the left aortic arch.

B.—A representation of a portion of the left aortic arch by the left subclavian artery.

C.—A non-division of the primary aortic stem.

FIG. 2.—Heart and blood-vessels, anterior view.

1, upper end of the incomplete interventricular septum ; 2, the aorta ; 3, the origin of the right pulmonary artery ; 4, the left common carotid artery ; 5, the right common carotid artery.

FIG. 3.—Thoracic aorta, posterior view.

1, the right subclavian artery; 2, the left subclavian artery; 3, the left pulmonary artery; 4, the pulmonary veins; 5, the thoracic aorta.

D.—A non-development of the infundibular or bulbous portion of the right ventricle, with which probably the non-development of the pulmonary stem is associated.

It is difficult to offer any explanation of the origin of the left pulmonary artery.

We are indebted to Dr John Thomson, physician to the Children's Hospital, for permission to examine the specimen and to record the facts regarding it.

Dr Thomson brought the specimen to the notice of Professor Keith, Curator of the Royal College of Surgeons' Museum, London. Professor Keith threw much valuable light upon the developmental explanation of the abnormality, and to him we are also indebted.

THE COURSE OF THE PHRENIC NERVE IN THE EMBRYO.

By M. AMIN, *Assistant Professor of Anatomy, School of Medicine, Cairo.*

THE phrenic nerve is a valuable structure in the embryo, for several reasons. Its fibres reach their termination—and hence the whole course of the nerve can be traced—at an earlier date than do the fibres of any other spinal nerve; and from the relation which the nerve presents to the pleura and pericardium, as well as to the diaphragm, it is of great service

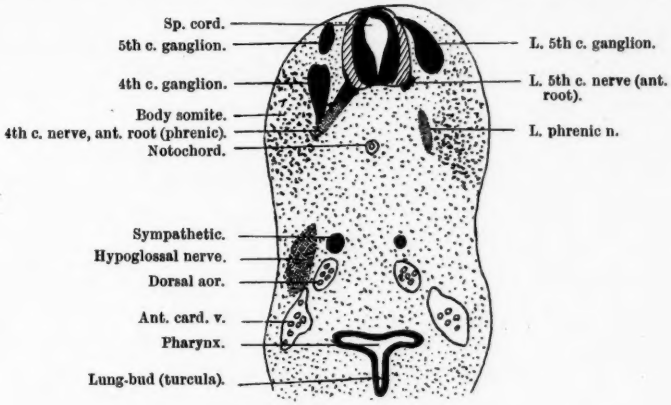


FIG. 1.

in tracing the development of these different portions of the cœlom, as well as the early stages of the development of the diaphragm.

The nerve cannot apparently be traced in embryos of less than 5 mm. maximum length, and in the following account a description is given, with figures, of the origin, course, and termination of the nerve as it was found in a 6-mm. embryo.

DESCRIPTION OF THE RIGHT PHRENIC NERVE.

Beginning with a transverse section at the level of the fourth cervical ganglion (fig. 1), the nerve was found arising from the anterior roots of the fourth cervical nerve as the latter takes origin from the spinal cord.

Placed lateral to each nerve (on the right and left sides of the embryo) is the remains of a somite.

As the nerve is traced downwards, it passes ventrally, and comes to lie behind the anterior cardinal vein; and at a still lower level it establishes a communication with the fifth cervical nerve, and comes to lie in a cup-shaped invagination at the junction of the anterior cardinal vein with the primitive subclavian vein from the limb bud (fig. 2).

The relationship at this level is that the nerve is mesial to the subclavian vein, for that vessel lies more in a dorso-ventral axis than in the

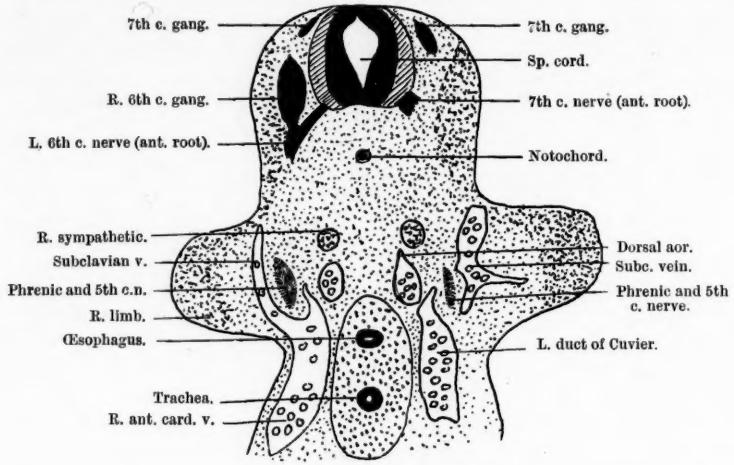


FIG. 2.

coronal plane. In sections beyond this level, the nerve retains a similar position, and then comes to lie lateral to the duct of Cuvier (fig. 3).

Further on, the nerve comes into relation with the early divisions of the cœlomic cavity, and lies between the antero-lateral recess laterally and the pleuro-pericardial passage medially (fig. 4).

The position of the nerve at this level is important, as the nerve is now coming to lie in the upper part of the arch connecting the anterior and posterior pulmonary ridges; but at this stage the nerve lies lateral to the lung bud, and posterior to the pericardial sac.

From the figure, evidence is afforded of the very extensive changes which occur at a later stage in connexion with the development of the lungs. In order to attain the adult relationships, the lung buds must at a later stage grow laterally, behind the phrenic nerve, and finally send their

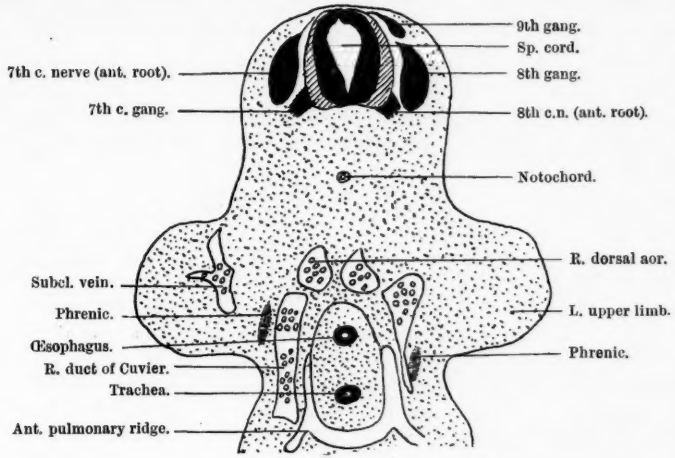

9th gang.
Sp. cord.
8th gang.
8th c.n. (ant. root).
Notochord.
R. dorsal aor.
L. upper limb.
Phrenic.
7th c. nerve (ant. root).
7th c. gang.
Subcl. vein.
Phrenic.
Œsophagus.
R. duct of Cuvier.
Trachea.
Ant. pulmonary ridge.

FIG. 3.

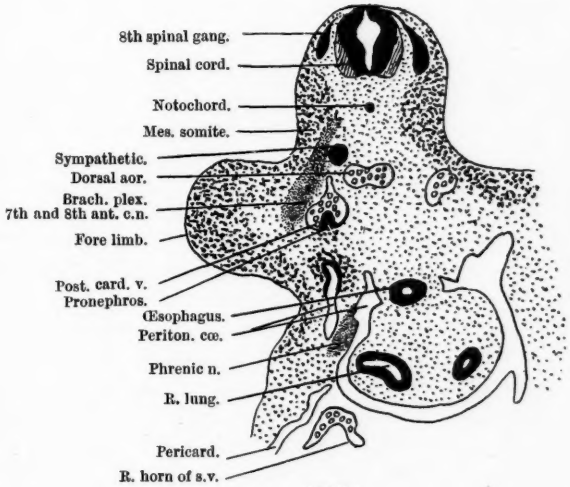

8th spinal gang.
Spinal cord.
Notochord.
Mes. somite.
Sympathetic.
Dorsal aor.
Brach. plex.
7th and 8th ant. c.n.
Fore limb.
Post. card. v.
Pronephros.
Œsophagus.
Periton. cœ.
Phrenic n.
R. lung.
Pericard.
R. horn of s.v.
Auricle.

FIG. 4.

anterior parts forwards, with the investing pleura, and so entirely alter the relationship present at this stage of embryonic life.

In sections below this level the nerve is found to terminate among the cells of the ventral aspect of the septum transversum, with the pericardium anterior and mesial and the anterior pulmonary ridge posterior to it (fig. 5).

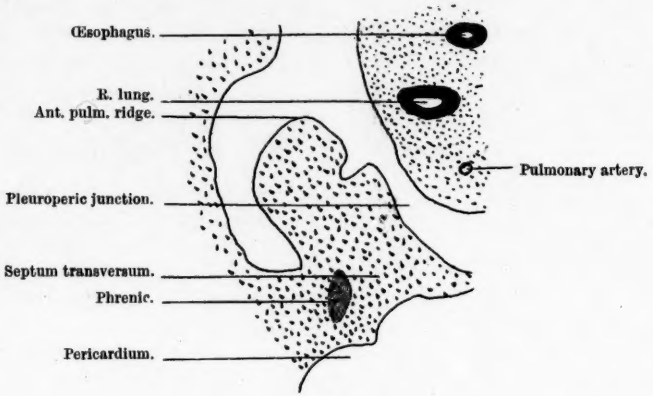


Fig. 5.

The figures illustrating the course of the nerve are obtained from projection drawings of sections at the various levels.

Lastly, I have to express my great thanks to Professor David Waterston of King's College, who kindly helped me much in working out this nerve, which I did in his laboratory at the King's College, London.